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JOURNAL OF ECONOMIC ENTOMOLOGY
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Color Perception in Insects

Presidential Address, Fifty-fourth Annual Meeting, American Association of Economic Entomologists

HARRY B. WEISS, *Trenton, New Jersey*

The importance of light in the economy of insects is so well-known that it deserves no extended consideration at this time. Even though the responses to light are influenced or overridden by such other factors as temperature, moisture, air currents, metabolism, chemotropism, etc., light as such still remains important. This importance is indicated by the size and development of the compound eyes, with their large receptive surface, in comparison with the volume of and the comparatively less developed central nervous system (Kennedy 1937). Entomologists, by the use of light traps, have long taken advantage of the positive phototropism of insects in order that they might be supplied with information on abundance, geographical distribution, seasonal distribution, number of broods, proportion of the sexes and the influence of temperature upon flight.

In the economic field for the past ten or fifteen years light traps have been utilized for the destruction of certain insect pests with varying degrees of control. In the case of the codling moth, *Carpocapsa pomonella* Linn., artificial light has been used not only in connection with electrocuting traps and bait pans, but also as a deterrent to egg deposition. The bud moth, *Eucosma ocellana* Schiff., and the fruit tree leaf roller, *Archips argyrospila* Walk., in apple orchards, have been reduced in numbers by light traps. And Driggers has reported upon the effect of artificial illumination on the oriental fruit moth under orchard conditions, stating that neither repellancy nor pronounced attraction of the moths was evident under the conditions of the tests.

In this work, which was done chiefly by Herms (1929, 1932) Headlee (1932), Collins & Nixon (1930), Collins (1934a), Collins & Machado (1937); Parrott & Collins (1934, 1935), Driggers (1932) and others, the sources of light were *Mazda* lamps of various wattages, sun lamps, and mercury vapor tubes. The intensity was reported usually in "foot candles," but nothing was mentioned about the spectral quality of the light, although Headlee (1932) found that the violet end of the spectrum stimulated female codling moths to apparently normal oviposition.

Mention might be made at this time of other recent experimental work with insects and light. Barber (1925), who studied the responses of European corn borer adults to light in egg laying, found that, in general, during constant light the adults lived for shorter periods and that a larger proportion of the females produced few eggs. Rudolfs & Lackey (1929), during an investigation of the effect of food upon the phototropism of mosquito larvae reported that the larvae of *Culex pipiens*, *Aedes sylvestris* and *A. canadensis* were positively phototropic when fed on a mixed diet. When fed on a pure ciliate diet they changed from positive to negative in two days. On a diet of dinoflagellates their photopositiveness was intensified and remained strong until near pupation.

The dark mealworm, *Tenebrio obscurus* Fab., which ordinarily lives in darkened environment, was utilized by Cotton (1930) in light experiments and when worms were exposed to continuous light from a 10 watt lamp, their rate of metabolism increased and their transformation to the pupal state was accelerated. It was found by Waitzinger (1933) that the life cycle of the silk worm, *Bombyx mori*, could be shortened from a few to several days depending upon the intensity of the light to which it was exposed. This author

states that the silkworm consists of various strains and genetic lines which react differently to light intensities and that light acts as an agency in the elimination of constitutionally inferior strains.

Sabrosky *et al.* (1933), in an effort to increase the generations and numbers of the northern grouse locust, *Acrydium aernosum angustum* Hancock, in greenhouses, discovered that exposure to continuous extra light, either "violet" or "white," accelerated the growth of the nymphs and that extra light in addition to higher temperatures was needed to break the winter diapause.

The reactions to light, intermittent and continuous, of *Drosophila* and other flies have been studied extensively by McEwen (1918, 1925), Dolley (1923), Mast (1923), Mast & Dolley (1924) and Klingbeil (1938). Without attempting to summarize the work of these authors it may be mentioned that McEwen found that *Drosophila* was not phototropic unless it was in a certain physiological state brought on or accompanied by activity. When the flies reached a certain degree of activity they became phototropic; Stehr (1931), in his work with several aquatic Hemiptera, found a high degree of variability among the species in their response to light, probably due to inhibitions and other effects of the central nervous system upon the responses.

Other authors have studied the relative sensitivity to light of different parts of the compound eye. Mast (1923), for example, in working with drone flies and robber flies discovered that the sensitivity of the ommatidia in the compound eyes of insects increased from the anterior to the posterior end and that there was a distinct difference in the sensitivity of different regions of the eye. Dolley & Wierda (1929), going a step further, claimed that the ommatidia located about the center of the compound eye of the drone fly, *Eristalix tenax*, are more than 55 times as sensitive to light as those near the anterior end and that the ommatidia at the posterior end are probably much more sensitive.

Hecht & Wolf (1929) demonstrated that for the honeybee the lower part of the compound eye is more sensitive to light than the upper part.

Differences in the degree of light adaptation are due in part to the movement of pigment in the iris cells. The response of insects to light depends upon the position of the iris pigment, which enables the insect eye to adapt its sensitivity to light over a wide range. The sensitivity of the iris pigment to light and the motor response of the insect are closely related. Collins & Machado (1935) have recently described the movement of the iris pigment in the compound eyes of the codling moth. When the eyes were exposed to sufficiently bright or continuous light, the iris pigment receded to a proximal position where it masked the retina so that enough light could not penetrate to produce a positive response. The moth was then light adapted. In the dark adapted state there was a more or less complete withdrawal of pigment from the retina to a zone extending from the proximal ends of the crystalline cones to the cornea. Some authors believe that a photochemical reaction in the pigment cells initiates the movement.

Various periods of time are required for complete pigment migration in different species. Collins (1934b) found that under natural light conditions in March, both light and dark adaptation in the codling moth required about one hour for completion. When artificial darkness was suddenly imposed dark adaptation was completed sometimes more quickly than under natural conditions. Wolf & Wolf (1935) report that the sensitivity of the light adapted eye of the honeybee increases rapidly during the first few minutes in darkness, then more slowly until it reaches a maximum level after 25 to 30 minutes. Uchida (1934), working on color changes in the eye of a long-horned grasshopper, *Homorocoryphus lineosus*, states that if light adapted insects are transferred to a dark room, the distal movement of the pigment cells and granules takes place rapidly during the first 20 minutes. It then slows down and does not reach a completely dark adapted state until 50 minutes have elapsed. When the dark adapted insects are illuminated he reports that the rate of proximal migration of pigment granules in the principal pigment cells is proportional to the intensity of the light.

What has been said so far is mainly by way of a brief introduction—to bring out some of the effects of light upon insects—to show the type of work that has been

done by entomologists and behaviorists, but principally to demonstrate the complexities of any work with light and insects, when it is only possible to measure the motor responses and not the effect of light upon the receptors directly. Not only are there problems connected with the physics of light, but one is dealing with organisms in different physiological states, and which are influenced simultaneously by the stimulation of other sense organs and the central nervous system. The variability of the reactions of different insects is, no doubt, due to these competing influences. In other words, a very complex chain of interrelated reactions takes place and we see the result only as a simple motor response.

The real subject of this paper, the behavior of insects to light of various wavelengths or colors, has been under investigation for many years. Frequently the conclusions drawn from different experimental set-ups have been the subject of controversy. Perhaps the main difficulty has been that of determining if the discrimination by the insects is due to the intensity of the rays or to their wavelengths or colors.

Entomologists have attacked this problem principally in two ways. Some have observed the tropisms of insects and others have trained certain species to come to particular colors for food. Some have neglected the external source of the color sensation which is physical and have described their results in terms of human color vision, which refer to sensations. Others, however, have worked with known wave-lengths and have safeguarded their work as much as possible.

This paper is a brief review of some of the results of the more important investigations. Lubbock (Avebury, 1929) established the fact that bees are able to distinguish one color from another and that they could be trained to associate the finding of food with blue or orange colored papers. Forel (1908) accomplished the same results with paper flowers. This work, however, did not rule out the possibility that the insects may have acted the way they did because of the relative brightness of the colors. Hess (1910) projected a spectrum on a parallel-sided glass container which contained imprisoned insects. He observed that caterpillars and adults of the butterfly *Vanessa urticae* and also bees went to the yellow-green color area. These insects left other regions of the spectrum for the yellow-green area and when disturbed they returned to the same zone. After discussing the color vision experiments of Plateau, Avebury, Forel, and others, Hess stated that they were mistaken about insects having color vision and concluded that as totally color-blind persons see yellow-green as the brightest part of the spectrum, his insects that went to the yellow green area were also totally color blind. In addition Hess determined the shades of gray or the luminosities that so exactly matched the luminosities from screens of certain colors that the insects went to one or the other without discrimination or failed to go to either. From this he concluded that various colors are of the same relative brightness to insects as they are to totally color-blind persons, and that insects lack color vision. Hess also worked with houseflies finding that the most stimulative region was in the blue and green.

Frisch (1924), who worked principally with an Asiatic species of honeybee, succeeded in training these insects to come to a given color for food and to pick out that color, among others, when no food was present. He used a series of pieces of paper of 15 shades from white through various grays to black. The bees were then conditioned to blue or some other color, by associating that color with a sugar-solution in a watch glass that was placed over the color. After conditioning was completed the blue paper without food on it was placed in various positions among the grays and in every case the bees gathered over the blue in search of food. Frisch found that bees conditioned to red or black did not distinguish between these two colors or dark gray and he decided that they were blind to red. He also discovered that bees conditioned to yellow failed to distinguish between yellow, orange and yellow green; and that bees conditioned to blue turned indiscriminately to violet or purple. He finally concluded that bees can distinguish all colors except red and certain greens which appear as darker or lighter grays to them and therefore that their color vision was identical with that of partially color-blind persons. Lubbock (Avebury 1929) also trained bees to associate the finding of food with certain colors. Haan (1928)

who experimented with monkeys and bees, stated that bees trained to go for food to papers of different colors make their selection on the basis of absolute brightness.

Turner (1910) also trained honeybees to come to certain colors and different patterns of the same color by using small wooden blocks painted with different colors and different patterns, and containing openings where honey was placed.

Pilkington Brothers, Ltd. (1930) found that red and yellow glass in windows considerably reduced the numbers of houseflies in buildings while blue and green were much less effective. In 1937, a patent was issued to W. S. Kell (1937) for dark blue or dark red fly paper, "for which the fly exhibits a preference." Two years before this patent, Freeborn & Berry (1935) published the results of tests in which a board was painted in squares with colors ranging from blue to red and including white and aluminum. The attractiveness of each color was indicated by the number of dots of excrement found on the squares. On this basis, dark blue was found to be the most attractive, followed by dark red, light gray and canary yellow. Other colors were less attractive.

Recent work by Fleming *et al.* (1940) on the relation of color to the effectiveness of Japanese bettle traps, developed the conclusion that traps painted yellow entirely were definitely more effective than those painted aluminum, white, light yellow, light blue, dark blue, pink, red, orange, reddish orange and varying shades of green. These authors stated that the addition of yellow to other pigments always increased the effectiveness of the traps, and suggested that "a beetle is better able to discern and avoid obstacles painted with some colors than with other colors." In other words, this implies that a yellow trap is more effective, because the Japanese beetle cannot see yellow, in many cases, well enough to avoid it, but that it can see other colors well enough to avoid them.

Various other examples of particular species preferring certain colors could be mentioned. Among these Wigglesworth (1934) states that when certain butterflies are offered gayly colored paper flowers, they prefer these before gray ones. The cabbage butterfly, for example, in search of food prefers blue and purple papers and to a less degree, red and yellow. It pays no attention to green, blue-green and gray. For egg deposition the female butterfly chooses emerald green to greenish blue papers.

From what has been presented so far, it is apparent that various authors believe that insects make their selections of colors on the basis of brightness; that insects are totally color-blind; that the color vision of insects is the same as that of partially color-blind persons; that certain species prefer dark blue and dark red, that others prefer green, others, yellow, etc. Little or nothing is known of the wave-lengths with which these authors worked. The results are expressed in terms of human color vision. In many cases no tests were made with ultraviolet which insects "see" and which is beyond the range of human vision. In addition, some authors covered their colored papers with glass. Light going through the glass was reflected back again. The glass also reflected colors from nearby objects. Lutz (1924) tested the colored papers used by Frisch and found that some of his greens and blues reflected ultraviolet, that his yellows and greens reflected red, and blue —all of which invalidated Frisch's color scale for insects.

As color vision is a matter of wave-lengths—we turn now to investigations wherein an increasing amount of attention was paid to this fact, and wherein an increasing improvement took place in technique and in testing equipment, and wherein ultraviolet was considered as a color, at least to insects. These investigations were concerned with that portion of the electromagnetic spectrum from about 2500 Å to 7000 Å, or from ultraviolet rays which are invisible to us to the longer invisible rays of infrared. Between the ultraviolet and infrared lie visible rays of violet, blue, green, yellow, orange and red.

As long ago as 1881 Sir John Lubbock (Avebury 1929) found that ants carried their larvae and pupae out of a region of relatively weak ultraviolet into one illuminated by longer wave-lengths. Lubbock set up a narrow trough illuminated by a spectrum extending from ultraviolet. through violet, blue, green, yellow, orange, to red. After adult ants and ant pupae were placed in the trough, the adults immediately began to carry their pupae from

the ultraviolet region to the red end. From this Lubbock realized that colors as seen by insects were not the same as colors viewed by man. Lubbock's work was later confirmed by Forel (1908). Hess (1920b) also demonstrated that bees and some other arthropods are sensitive to ultraviolet. Using a mercury-vapor lamp, he was led to believe that the ultraviolet from this source was enormously more stimulating than ordinary light. He concluded (Hess 1920a) that the general sensitivity of arthropods to ultraviolet was due to a fluorescence of the outer parts of the ommatidia, believing that the short waves were thereby changed to longer ones and that the animals did not have true ultraviolet vision.

When Lutz & Richtmyer (1922) reported that *Drosophila* was sensitive to ultraviolet light of from 3400 Å to 3900 Å they expressed the opinion that the question could still be raised that such photosensitiveness might be due to fluorescence of eye media identical to that undergone by the human eye when exposed to ultraviolet light. However, on the basis of additional experiments Lutz & Grisewood (1934), in 1934, at which time they reported that *Drosophila* behaved as if it saw 2537 Å in the ultraviolet, stated that there was still a possibility that the fly did not see such light, but reacted to a fluoresence set up in the eye by the radiation. Because of the difficulty of mounting the cornea of the *Drosophila* eye, they were forced to use the cornea of a large fleshfly, and of a honeybee. Spectrograms of the radiation transmitted by the cornea of each of these insects showed that they were particularly transparent to 2537 Å and that such a wave-length reached the inner elements of the eye. When the 2537 Å beam was allowed to fall upon a mass of crushed *Drosophila* eyes there was still no fluorescence—at least not visible to humans. Radiation as short as 2537 Å does not occur in sunlight.

Mayer & Soule showed that the larvae of the Monarch butterfly, *Danais archippus*, are photopositive to ultraviolet and Kühn & Pohl (1921) trained honeybees to come for food in a narrow trough illuminated by ultraviolet of a wave-length of 3650 Å. After training, the food was removed and the entire spectrum projected upon a sheet of white paper. The bees that came for food which was not there, collected, for the most part, on the place subjected to the wave-length 3650 Å. These authors concluded that four regions of the spectrum are distinguishable by bees, the yellow and green, the blue green, the blue and violet, and the ultraviolet. Additional work by Kühn (1927) led him to state that the vision of the honeybee extends to at least 3130 Å and that this wave-length is not recognized as distinct from 3650 Å but is differentiated from those longer than 4000 Å. The use, by Kühn (1927), of spectral colors gave him, in regard to red, the same results obtained by Frisch, who used colored papers. In addition, he stated that bees do not respond to wave-lengths longer than 6500 Å. He defined the four regions distinguished by bees as 3130–4000 Å (ultraviolet), 4000–4800 Å (violet blue), 4800–5000 Å (blue green), 5100–6500 Å (red, yellow and green), Kühn & Fraenkel (1927), in a later paper, stated that there were three shades of difference of color qualities distinguishable by bees, these occurring in the region comprising red, yellow and green, and in the blue and violet region. This, plus the findings of Bertholf (1931) brings the number of chromas which bees are supposed to be able to distinguish to eight.

Lutz (1924), in his study of the extent to which flower-visiting insects see ultraviolet, carried out tests with numerous flower-visiting insects. He put the insects into a box having a window at each end. These windows consisted of various light-filters. The top of the box was glass surrounded by a light-tight hood within which he could put his head and observe what was going on, without admitting stray light. This was used in the field with insects that were visiting flowers at the time of the test. Many of his insects behaved as follows:

They went from dark to clear glass, from dark to ultraviolet, from dark to blue, from blue to ultraviolet, from dark to green, from green to ultraviolet, from dark to red, from red to ultraviolet. And when at ultraviolet they would not leave to go to clear glass. Some individuals especially of the Lepidoptera would not react to any types of illumination. Most of the flower-visiting insects, especially bees and wasps reacted to all tests. The conclusion is inescapable that many insects react positively to red, green, yellow,

blue and ultraviolet; that they see ultraviolet better than other radiations. Whether they see these radiations as colors or as different degrees of brightness is unknown. But having the ability to see ultraviolet which we cannot see, it is certain that their reactions should not be described or interpreted in terms of normal human vision. In this work Lutz used filters of known transmission characteristics, the ultraviolet filter transmitting from 3200 to 4300 Å. In addition Lutz (1941) trained honeybees to come to a white card, reflecting certain ultraviolet wave-lengths, for food, and stingless bees (*Trigona*) to distinguish between ultraviolet patterns, reflected from sunlight, one of which marked the site of the nest (Lutz 1933).

The effect of monochromatic light on the ant *Formica dakotensis specularis* (Emery) was determined by Abbott (1927) who used four definitely determined light intensities and four color filters of known transmission. The period of time required by the ants to move their pupae when light of a given wave-length and intensity fell upon them was considered inversely proportional to the stimulating value of the light used. From Abbott's results, what appears to us as yellow had the greatest stimulating value and white light was second to yellow. His results with green and red were irregular. The source of light was a 100-watt lamp and as nothing was mentioned about its spectrum, perhaps this was not taken into consideration.

The response of the oriental peach moth and codling moth to colored lights was tested by Peterson & Haeussler (1928) who found that when moths of both species were given the choice of light from violet to red and if the ratios of the intensities were approximately equal, nearly all of the moths went to blue and violet. Few or no moths went to red. Orange and yellow were unattractive when compared with blue and the same was true for green. Violet was preferred to blue. A few tests made with the oriental fruit moth and ultraviolet indicated that this color was highly attractive. Although the results are not reported as responses to definite wave-length bands, the wave-length ranges of the filters were recorded.

In this paper on the reactions of arthropods to monochromatic lights of equal intensities, Gross (1913) reports that blow-fly adults, *Calliphora erythrocephala* Meigen, fruit-fly adults, *Drosophila ampelophila* Loew, larvae of the wood leopard-moth, *Zeuzera pyrina* and a noctuid moth, *Feltia subgothica* Haw., are all photopositive, the order of the effectiveness of stimulation being blue (4200–4800 Å), green (4900–5500 Å), yellow (5700–6200 Å), and red (6300–6550 Å). The larvae of the blow-fly were photonegative to all four wave-lengths or colors, the order of effectiveness being green, blue, yellow and red. Using cockroaches, *Periplaneta americana* Linn., Gross found that they were photopositive to blue light, photonegative to green and yellow, and indifferent to red.

Bertholf (1932) investigated the relative efficiency, of different regions of the spectrum, in stimulating *Drosophila*. He found that beginning with the longer wave-lengths, their efficiency was very low. It started to rise at about 5750 Å (yellow) and increased to a maximum at 4870 Å (blue-green). From 4870 Å it declined at 4250 Å (violet). From then on it rose at 3650 Å (ultraviolet) and then declined rapidly at 2300 Å (ultraviolet) except for a slight rise at 2540 Å (ultraviolet). The two peaks of stimulative efficiency were at 3650 Å (ultraviolet) and 4870 Å (blue-green) the ultraviolet peak being five and one-half times higher than the one at 4870 Å (blue-green).

In 1931 Bertholf (1931) reported the results of his comprehensive study of the reactions of the honeybee to the spectrum visible to us and found that the spectrum for this insect extends from 4310 Å to at least 6770 Å with the point of maximal stimulative efficiency at about 5530 Å. In terms of color this means that it extends from violet to red and that the most stimulating part of the visual (to us) spectrum is yellow green. Bertholf also (1931) investigated, in part by training, the chroma vision of the honeybee, or its ability to distinguish between colors of the same brilliance, and his results confirm the findings of Lubbock, Frisch, Kühn and others, and more clearly establish the presence of chroma vision in bees. In addition Bertholf by additional experimentation, found that bees are able to differentiate between two illuminated areas when the brightness of one is reduced to at least 70 per cent of the other. Frisch and Kühn concluded that only enormous differences

in brightness were distinguishable by these insects and Hess thought that the acuteness of bees was similar to that of man.

While on the subject of brightness mention should be made of the observations of various entomologists relative to the increase in the numbers of potato aphids, *Macrosiphum solanifolii*, on bordeaux sprayed plants in comparison with unsprayed plants and to the conclusion of Folsom (1927) that initial infestations of the cotton aphis are due to the positive phototropism of winged females to white substances used as sprays or dusts. Moore (1935) under laboratory conditions found that there was no difference in the wave-lengths of light reflected from sprayed and unsprayed potato leaves, but that more intense light was reflected from the sprayed leaf surface. In a later work (Moore 1937) he demonstrated that the responses of the potato aphid followed the inverse square law of light intensities and that the increased intensity of light reflected from sprayed surfaces was responsible for attracting more aphids. Using the cabbage aphid, *Brevicoryne brassicae*, he was able to demonstrate by the use of white, green, red and black dusts, that red and especially black dust were effective in reducing infestations.

In a subsequent study Bertholf (1931) reported upon the stimulating effect, of different wave-lengths in the ultraviolet spectrum on the honeybee, and determined that efficiency is the greatest at 3650 Å, with the spectrum extending down to 2970 Å. By joining the results of both pieces of work, Bertholf demonstrated that there are two peaks where the efficiency of the wave-length are most effective, one at 3650 Å in the ultraviolet and a secondary one at 5530 Å in the yellow green, the former being about 4.5 times as effective as the latter. All Bertholf's work is characterized by a full appreciation of the physics of light and by the use of apparatus and methods designed to give accurate results. In determining the relative stimulating efficiency of lights of different wave-lengths, Bertholf kept the energy of the test wave-length constant and varied the standard (white) until the lights were equally attractive. He also tested each wave-length against a fixed intensity of white and after finding the ratio of attractiveness, he substituted a white of variable intensity and determined the intensity which, when tested against the standard, had the same ratio of attractiveness as that of the wave-length.

Sander (1933) made the standard and the test wave-length equal in intensity and used the number of test animals attracted to each as a measure of relative efficiency. He also adjusted the intensity of the test wave-lengths until they were equal in attractiveness to a standard of fixed intensity and quality. He found that when light of equal energy was used at all parts of the spectrum there was no trace of the high maximum at 3650 Å and he believed that his method was better than using light of unequal energy over different parts of the spectrum and then calculating the relative effect of equal energies. In Sander's method of making all lights of equal intensity and then testing each wave-length against all others, his bees responded to two maxima of stimulation at about 5700 Å (yellow) and 4600 Å (blue) with a minimum at about 5200 Å (green). From 4700 Å there was a steady decline into the ultraviolet.

Cameron (1938) in his recent and careful work on the reactions of the housefly to light of different wave-lengths reported that this insect was more strongly activated by ultraviolet light of wave-length 3650 Å, than by any other portion of the spectrum with which he worked and which extended from 3022 Å to 5780 Å. The stimulating effect declined rapidly and then slowly from 3650 Å in the ultraviolet as the longer wave-lengths were reached, and it also decreased on the short wave side of 3650 Å. Cameron applied to his results the three methods of analysis used by former workers and found that qualitatively all three methods gave identical results in showing that the peak of attractiveness was at 3650 Å, with a rapid decline on both sides of this wave-length. He concluded that it is impossible to compare the results obtained by different methods and that the true quantitative relationship between the various colors or wave-lengths is still a matter for the future.

Although the honeybee has been a favorite subject for wave-length experimentation, various other insects have been studied from the standpoint of color response. For example Kelsheimer (1932)

in studying leafhopper response to colored lights used 25-watt electric light bulbs of red, brown, buff, ivory, green and blue. He stated that ivory attracted 453 leafhoppers out of a total of 909. Green was second in point of attractiveness followed by brown, buff and red. His blue bulb was a failure because its color covering did not permit the transmission of the same intensity of light as the other bulbs. No information was given about the spectral quality and quantity of the energy from the 25-watt bulb, nor as to how it was changed when it passed through the colored glasses. Knowing nothing of the wave-lengths or of the relative physical intensities of the sources, it is not possible to evaluate the results, except in terms of colors as we seen them. Kelsheimer reported that when the humidity increased over 83 per cent the insects ceased coming to light.

Herms and Ellsworth (1934) reporting upon the use of colored light in trapping various insect pests in the field state that the Clear Lake gnat *Chaoborus lacustris*, responded about equally in number to various colored lights of equal intensity (60-watt), the wave-lengths ranging from 3500 Å to 7000 Å, without any apparent peak of response. Of two blue lights which had an intensity ratio of 30 to 8, the former was more effective. Of two red lights with intensity ratio of 30 to 8, three times the number of gnats came to the more intense light. These authors advance the thought that if various species of insects respond to particular colors, that a high degree of selectivity can be achieved through the use of monochromatic light. While there is no reason for thinking that all species will behave in an identical manner to different wave-lengths of light—it appears from later work that a great many have a similar behavior pattern to color. These authors report a reduction in the worminess (codling moth) of apples on trees exposed to blue light, and also that after four nights' trapping, in a fig drying yard, a dark blue light captured 1578 *Ephestia figulilella* while a lighter blue captured 739. A field of artichokes illuminated by four midnight blue lights declined steadily in worminess from the effects of the artichoke plume moth, *Platyptilia carduidactyla*, and the grape leaf hopper came in somewhat larger numbers to red than it did to blue and white although blue alone captured enormous numbers. These interesting results would have been much more valuable if they had been accompanied by information showing the wave-lengths in Ångstrom units to which these insects responded and if the relative radiant intensity of the source lamps had been given for different points in the spectrum, because different sources of light emit different amounts of energy at different wave-lengths.

In later work with the Clear Lake gnat Herms (1937) found that of two red discharge tubes in a ratio of 3 to 1 in intensity, the one of highest intensity attracted approximately three times as many gnats as the lower. Regardless of the red color the increased intensity increased the number of gnats that were attracted. In this case, although the increased intensity may have been responsible in part for the increased captures, the so called "red" may have masked other colors that were present, and had a part in stimulating the insects.

In their tests of the kind of radiation most attractive to the codling moth Marshall & Hienton (1938) report that large amounts of ultraviolet radiation add to the attractiveness of lamps in light traps. When ultraviolet was screened out blue and violet alone were just as attractive. The ultraviolet radiation from the lamps used by these authors extended from 2483 Å to 3663 Å with the largest amount of energy coming off from 3129 Å to 3668 Å. Their blue and violet extended from 4000 Å to 5060 Å with the largest output from 4047 Å to 4358 Å. In addition, these authors determined that by increasing the size of the luminous area and by increasing the intrinsic brilliance a greater number of insects was attracted and caught.

In tests dealing with the reaction of the corn ear worm moth *Heliothis armigera* (Hbn.) to light traps, Carruth & Kerr (1937) using 3 types of light sources, a 75-watt tungsten, a 25-watt mercury vapor, and a 60-watt mercury vapor lamp found that the mercury vapor lamps each attracted more moths than the tungsten lamp. The mercury vapor lamp, of course, emitted some ultraviolet light. These authors state that the numbers of moths captured were directly influenced by mean night temperatures.

Headlee (1937) in a study of the attrac-

tion of mosquitoes to sources of radiant energy determined by experimentation and calculation that the attraction power of red light (5804–7174 Å neon lines) as measured by the number of mosquitoes caught per microwatt of energy was approximately 6 times the number that would have been taken per microwatt in white light (4000–8000 Å); that the number attracted per microwatt in green-yellow (5461 Å, 5790 Å mercury lines) was approximately 12 times as many as would have been caught per microwatt in white light; and that the number attracted by blue light (4047 Å, 4359–5461 Å mercury lines) was 21.5 times as large as would have been taken per microwatt in white light. Headlee stressed the importance of wave-length, and intensity, and stated that it appears to be possible to make any wave-length that is attractive at certain intensities, highly repellant by increasing the intensity beyond a certain point. He also stressed the fact that the wattage of a lamp is not an accurate measurement of the intensity of the energy emitted, a fact frequently disregarded by entomologists.

The European corn borer moth has received considerable attention from various entomologists from the standpoint of its behavior to light. Kelsheimer (1935), who studied its responses to colored lights, reported that when his color filters were arranged in the ascending order of wave-length and when the light transmitted through the filters was of uniform intensity, the moths responded in greater numbers to the short wave-lengths. In other words, the blue light attracted more than the red at the opposite end.

Kelsheimer knew the relative spectral distribution of the radiant energy of his source lamps and the transmission of his color filters and his lamps were adjustable so as to compensate for intensity. Under the conditions of his experiments, although ultraviolet attracted the most moths the peak of attractiveness in this wave-length region was not pronounced in comparison with the longer wave-lengths immediately following. I think that his results would have been sharper if the range of transmission of his filters had been shorter. While it is impossible to obtain strictly monochromatic filters, some are better than others.

Both laboratory and field work were done by Ficht & Hienton (1941) on some of the factors involved in the flight of European corn borer moth to electric traps. They found that by increasing the intensity (in foot candles) of white light (250-watt CX lamp) they were able to catch more moths in about the same ratio as that of the intensities. They also found that by increasing the diameter of the luminous area a greater number of moths was attracted. They found also that the moths had no preference for ultraviolet radiation of 2967 Å, at least this radiation did not increase the attractiveness of the light source. The same was true for radiant energy below 3200 Å. Furthermore the moths came in greater numbers to lamps radiating the greater percentage of their visible energy in the violet blue band of the spectrum (3800–5000 Å) than to lamps radiating the greater part of their visible radiation in the orange-red band (6000–7600 Å). No mention is made of ultraviolet of 3650 Å which other authors found so effective and apparently this wave-length was not tested by itself.

According to Priebatsch (1933) changes in the body coloration of the walking stick *Dixippus morosus* occur upon a reduction in the intensity of light stimulating the lower ommatidia. Under natural conditions the lower half of each eye is darkened and the upper half is brightly illuminated. When both eyes are shellacked, changes in body coloration do not occur. This author states that although "green" is least effective of all rays in the dispersion spectrum when it stimulates the eyes from below, it is the most effective of all, when it reaches the eyes from above. Furthermore the curve of stimulating efficiency for an equal energy spectrum reaches a peak in ultraviolet and declines regularly toward the long wave-lengths. This author's results imply a relationship between light entering the eyes and body coloration and suggest that the influence of the shorter wave-lengths varies with the intensity of illumination.

Hallock (1936) reports that lights of short wave-length near the violet end of the spectrum are most attractive to the Asiatic garden beetle and Dirks (1937) in his biological studies of Maine moths by light trap methods found that lamps which transmitted light in which ultraviolet rays were present caught the largest number of specimens.

Porter (1941) who studied the kinds of light that were most, and least, attractive to nocturnal insects states that for equal amounts of light ordinary red light attracts the smallest number of insects. Gui *et al.* (1942) in their work on the response of insects to color, intensity and distribution of light, say that lights of all colors tested were found to attract insects to a greater or lesser degree and that the colors for which comparable information is available arrange themselves in the order of most to least attractiveness, as blue, white, yellow, red.

During the past three years, Weiss *et al.* (1941, 1942) have tested in the laboratory the group behavior, in large numbers, of over fifty species of insects to light of different wave-lengths. Most of them belonged to the Coleoptera, but some were in the Orthoptera, Homoptera, Hemiptera, Diptera and Lepidoptera. The color or wave-length was determined by the passage of light from source lamps (40-watt *Mazda*) through appropriate Corning monochromatic filter glass combinations. The physical intensity (as distinct from human visual intensity) was regulated by the distance between the lamp source and the filter combinations. These combinations limited the light to relatively narrow bands of the spectrum. Knowing the transmission characteristics of the filter combinations and having a spectral analysis of a 40-watt, 115-volt incandescent lamp (which gave the radiant intensity at any given point in the spectrum in physical units) a formula was worked out which enabled the lamps to be set with respect to the filters so that the light transmitted by the filters was of equal physical intensities, although it was impossible to assign any physical unit of measurement to the quantity of transmitted light.

The insects, mostly photopositive species were exposed to ten wave-length bands of equal physical intensities in that part of the spectrum from 3600 Å to 7400 Å or from ultraviolet to infrared. When the insects were introduced to the colors one foot away from the filters the peak response took place at 4700–5280 Å (blue-blue-green) and usually declined on each side. When they were introduced at six feet from the filters, the peak response took place at 3650–3663 Å (ultraviolet) and declined fairly sharply toward the longer wave-lengths. Sometimes a large or small secondary peak occurred at about 4700–5280 Å (blue-blue-green). In other words when the introductory intensity was changed, the behavior pattern changed in that portion of the spectrum particularly from 3650 Å to 5550 Å (ultraviolet to yellow green). The remainder of the spectrum (to 7200 Å) from yellow to infrared was significantly unattractive, at equalized intensities. These statements apply generally to most of the 50 species that were tested.

The behavior of the potato beetle and the Japanese beetle in the presence of ultraviolet and blue-blue-green (to which they were most sensitive) in competition with each other indicated that the response of these insects to the wave-lengths producing the sensation of these colors in man, varied in accordance with the introductory intensities. In other words, when the physical intensity of the ultraviolet was strong most of the insects went to blue-blue-green. When it was weak they went to ultraviolet. Additional tests with the Japanese beetle indicated that certain wave-lengths in the so-called red end of the spectrum at intensities of 100 are more attractive than ultraviolet and blue-blue-green at intensities of 3. This red end of the spectrum can also be made more attractive to the potato beetle by increasing the intensity of the color to which the insect is first exposed. It was also found that the potato beetle and the Japanese beetle in the absence of a favored color will respond to all test colors except infrared.

Finally, various investigators have studied the spectra of luminous animals and Harvey (1940), who has summarized their findings, states that the beetle *Pyrophorus noctilucus* has a spectrum extending from 4680 Å to 6400 Å chiefly in the yellow and green. In the firefly *Photinus pyralis* it extends from 5100 Å to 6700 Å (green, yellow, orange, red) and in *Photuris pennsylvanica* from 5100 Å to 5900 Å (green, yellow). The spectrum of the glow-worm (*Lampyridae*) as given by Ramdas and Venkiteshwaran (1931) is a single band from 5290 Å to 5860 Å (green, yellow). These spectra of American and European fireflies which contain no blue or ultraviolet are apparently quite effective as mating signals.[1]

[1] John B. Buck reported recently that each of 13 species of Jamaican firefly emits light consisting of a continuous band, within the limits of 5000 to 6000 Å. (Proc. Roches. Acad. Sci. 8 (1); pp. 14–21, 1941.)

Almost nothing has been said about the apparatus and methods which the investigators used in arriving at their conclusions. This is because of the great diversity in the type of equipment, which varied from simplicity to complexity, from colored papers to spectroscopes, from no or incomplete knowledge of intensities to thermopile and galvanometer readings, from no qualitative or quantitative characteristics of light sources to complete knowledge of such sources, from no information about the transmission characteristics of filters to complete facts about them, from inflexible to flexible apparatus. Some work was done entirely in the laboratory. Other work was done in the field. A few investigators were concerned entirely with the ability of insects to discriminate between colors. These guarded their work as carefully as possible against errors. Others were concerned with only a few colors that could be used to advantage in trapping insects. Some facts were collected after patient research. Some were incidental to other work. The physical intensities of the wave-length were equalized by different methods. Sometimes they were unequal and the effect of equal energy was arrived at by calculation. The test wave-length bands were either narrow or broad. Seldom were they strictly monochromatic. Test insects were used singly five or more times or a hundred, more or less, were used at one time. In the field the number of insects collected by light traps was used as an indicator of color preference.

With such varying standards and lack of standards it is difficult to put many of the results on a comparable basis, nevertheless certain conclusions may be drawn.

Many insects behave as if they have color or wave-length discrimination, both in the laboratory and in the field. It is understood of course that we have no knowledge of the sensations of insects when they view the wave-lengths that produce certain color sensations in man. Many insects are sensitive in varying degrees to a spectrum extending from about 3600 Å to about 7000 Å (ultraviolet to infrared). *Drosophila* is photopositive to 2537 Å in the ultraviolet. The honeybee is photopositive to at least 2970 Å in the ultraviolet, and its susceptibility declines to zero at about 6450 Å.

Bertholf, by training bees, was able to obtain evidence leading to the conclusion that bees distinguish differences in brightness and found that trained bees can differentiate between two illuminated areas when one is as much as or more than 4 times as bright as the other. Untrained bees also respond to differences in brightness but there is little quantitative information on this subject. Work of Folsom and Moore with aphids indicates that brightness discrimination may be important.

Under the influence of equal intensities but different wave-lengths, the most stimulating part of the spectrum for many species is ultraviolet at 3650 Å. The peak of stimulative efficiency is highest at that point and declines sharply to the neighborhood of 4400 Å (violet-blue). Sometimes, but not always, there is a minor, secondary peak at 4920 Å (blue-blue-green) or 5550 Å (green-yellow) or 5150 Å (green) according to various investigators. The remaining longer wave-lengths (yellow to infrared) are relatively unattractive. For the honeybee there is a difference of opinion concerning whether the secondary peak is at 5700 Å (yellow) or 5550 Å (green).

There is also a difference of opinion as to the relative stimulating efficiency of ultraviolet at 3650 Å. The qualitative results of various authors are in harmony but their quantitative results are not—due to different methods of approach and analysis and perhaps in part to variations in the susceptibilities of the insects themselves at different times. However most authors agree that the comparative stimulating efficiency of ultraviolet is very high.

It has also been brought out that many insects will respond positively in greater numbers to the shorter of any two wave-lengths (between 3650 Å and 7000 Å) that are offered to them—where the physical intensities of both are equal and provided that the intensity of neither is great enough to cause repellency. In other words, they will go from red to orange, from orange to yellow, from yellow to green, from green to blue, from blue to violet, from violet to ultraviolet.

If the intensities of the longer wave-lengths are sufficiently greater than the intensities of the shorter wave-lengths—such species as the Japanese beetle and potato beetle will react positively and in greater numbers to the longer wave-

lengths of increased intensities. This applies to other species as well.

In view of what has been presented it is apparent that many species behave as if they have wave-length or color discrimination. With the physical intensities of the colors equalized and at certain intensities, at which the insects first see the colors, an almost uniform type of behavior pattern takes place, with the most stimulating part of the spectrum being confined to certain of the shorter wave-lengths, particularly from 3650 Å to 5280 Å (ultraviolet to green). If the intensities at which the insects first see the equalized physical intensities are changed—then the behavior pattern changes. In other words, if the insects are introduced close to the equalized physical intensities of various wave-lengths, one type of behavior pattern is produced. If they are introduced farther away, another type is produced.

These and other types of behavior to colors indicate that the stimulating values of the wave-lengths may be due in part to their apparent luminosity as determined by the physical intensity plus the wave-length. However, apparent luminosity can only be inferred from the behavior of the insects. If such an inference is correct we then arrive by another route at nearly the same conclusion of Hess, namely that insects have no color discrimination and that they are sensitive to different degrees of brightness and that the shorter wave-lengths are brighter to them than the longer ones. However, Hess did not suggest that brightness was a product of both wave-length and intensity. On the other hand their behavior to colors may be due to some photochemical change effected by wave-length and intensity upon their visual apparatus. Of the two factors, wave-length and intensity, the relative importance of each can only be determined by additional experimental work and a study of the motor responses of the insects. Even after that we will still be confronted with the fact that we do not know anything about the effect of either intensity or wave-length upon the photoreceptors of the insect in producing the sensation of brightness, if such a sensation is produced. For many insects ultraviolet (3650 Å) is the most stimulating wave-length and *Drosophila*, for example, responds more readily than many other species to weak intensities of ultraviolet (3650 Å). In fact the stimulation given to many insects by ultraviolet appears to be nearly equal to the stimulus given by the remainder of the spectrum to which they are sensitive.

In view of the importance of ultraviolet light as a stimulant—the significance of such wave-lengths in sunlight and in the light reflected from foliage and flowers is of extreme interest. The idea that conspicuous floral colors have evolved by natural selection because they facilitate the visits of pollen-carrying insects, although no longer held, in many quarters is still in circulation and is still being taught in some places. This idea is based on the assumptions that insect vision and normal human vision are identical—and that insects see colors as man sees them, neither of which is true.

Both Richtmyer and Lutz (1924) have studied the nature of the light reflected by flowers. Richtmyer's work gives detailed information concerning the exact wave-lengths involved in ultraviolet reflection for a number of flowers. Observations on about 100 flowers by Lutz indicate that "a majority of the 'yellow' and many 'red' and 'purple' flowers are strongly ultraviolet, while few or no white flowers are." Few "blue" flowers are ultraviolet, mostly only those that have much red pigment.

These yellow, red, and blue flowers are of such colors only to persons with normal vision. Lutz, who photographed flowers through color filters, states that most flowers reflect considerable green, also that white flowers reflect large amounts of red, that most yellow flowers "are as strongly red as are red flowers."

Lovell (1918) in his book "The Flower and the Bee" lists the colors, in terms of human vision, of slightly over 4000 North American flowers in six color groups. Lutz calculated the percentages as follows:

Green	31 per cent
White	24 per cent
Yellow	20 per cent
Red	6 per cent
Purple	11 per cent
Blue	8 per cent

Of the 4000 flowers almost 3000 or three-fourths are supposed to be either insect or self pollinated. Lutz reduced this 3000 group to percentages as follows:

Green	8 per cent
White	32 per cent
Yellow	27 per cent
Red	8 per cent
Purple	14 per cent
Blue	11 per cent

As Lutz points out from his photographic work, white, and most yellow flowers reflect large amounts of red and that although 8 per cent of the conspicuous flowers are red to us, "nearly 80 per cent of such flowers are spectroscopically strongly red." Of the conspicuous flowers about 11 per cent are what we call blue, but yellow and red flowers reflect a weak blue and white flowers reflect blue strongly, so Lutz concludes that instead of 11 per cent of the conspicuous flowers being blue, closer to 50 per cent of them reflect this color strongly.

In the light reflected by one flower or another, all colors are found, from ultraviolet to red. Many yellow, red and purple flowers are strongly ultraviolet, Lutz estimating that, on the whole, "about 30 per cent of conspicuous flowers are strongly ultraviolet." Of the reflected wave-lengths from flowers, green to red are commoner than ultraviolet to blue and flower-visiting as well as other insects do not "see," or are not stimulated by, green to red as they are by ultraviolet to blue, and especially by ultraviolet, to which they are highly sensitive. The question then is, does this color play an important part in the sensation which insects receive when they "see" one of the thirty per cent of the conspicuous flowers that reflect ultraviolet? Bertholf (1931) believes that for the honeybee, this is true, especially as the ultraviolet energy of sunlight amounts to one-fifth of the sun's spectrum visible to the bee and considering that ultraviolet is "four and one-half times as efficient in its stimulation as the rest of the energy."

Although ultraviolet may be of importance to bees and to other insect visitors of flowers that reflect ultraviolet, there are many insects that 4espond to ultraviolet in the laboratory more or less like the bee, but which visit and feed upon plants that reflect little or no ultraviolet.

The reflection, absorption and transmission of different parts of the spectrum by vegetation have been studied by Pokrowski, Shull, Hibben, Seybold and others (Popp & Brown 1936). A quite recent study by Kalitin (1941) made in the field upon leaves on such trees as maple, linden, willow, birch, dogwood, oak, poplar, cherry and others, reveals that the absorption of incident sunlight varies from 36 to 86 per cent, the transmission from 6 to 38 per cent and the reflection from 9 to 34 per cent—all depending upon the great variability of leaves, and the quality of the radiation falling upon them at different seasons. In the summer the absorption is greatest and reflection and transmission are both comparatively low. In the fall the absorption declines and the reflection and transmission increase. More radiation is reflected by lower than by upper leaf surfaces.

Seybold (Popp & Brown 1936) using green leaf sections and white leaf sections of 10 species of variegated plants found that for the green leaf sections the absorption of the incident light was about 91 per cent at 3360 Å (ultraviolet), 87 per cent at 4360 Å (violet, blue), 76 per cent at 5090 Å (green), 76 per cent at 5780 Å (yellow), and 78 per cent at 6440 Å (red). The transmission ranged from 0 at 3360 A (ultraviolet) to 9 and 10 per cent at 6440 Å (red). The reflection, in which we are particularly interested, was 9 per cent at 3360 Å (ultraviolet) and ranged from 11 to 14 per cent for the remaining wave-lengths.

It is apparent that for green leaves absorption increases as the wave-lengths become shorter, leaving less of the shorter wave-length to be either transmitted or reflected. Shull (Popp & Brown 1936) using a wide variety of green leaves obtained maximum reflection in the region 5400–5600 Å (green-yellow) and Hibben (Popp & Brown 1936) reported maximum reflection in the region 5500–5600 Å (green-yellow). From these few examples from a larger body of supporting facts and in spite of the fact that some of the investigators used filters with comparatively long transmission ranges it appears that little ultraviolet is reflected from the surface of green foliage and that the maximum reflection is at 5400–5600 Å (green-yellow), a region not particularly stimulating to many insects under laboratory conditions and a region having a stimulating effect far below that of the shorter wave-lengths, particularly ultraviolet.

In addition to the reflection from vegetation insects must be influenced greatly by solar radiation which covers a much wider range of wave-lengths than insects

react to. This radiation by the time it reaches the surface of the earth is characterized by its great variability, due to variation in distance between the sun and the earth, the influence of the atmosphere of the earth, and the presence of dust, smoke and foreign materials. Absorption takes place in the atmosphere due to air mass, water vapor, and ozone. The earth's atmosphere is completely opaque to the radiation at the extreme ultraviolet end of the spectrum, thought by some to be due to absorption by ozone, which is our defense against dangerous ultraviolet wave-lengths. Of the total radiation from the sun, less than 0.1 per cent lies short of 3130 Å, from 1 to 5 per cent is in the ultraviolet, from 41 to 45 per cent is in the visible part of the spectrum and from 50 to 58 per cent is in the infrared (Brackett 1936). However, the shorter wave-lengths of light contain greater amounts of energy than the longer wave-lengths, and photochemical reactions are produced more often by ultraviolet than by blue, and more frequently by blue than by green or red light (Farrington 1936). The energy in electron volts of some of the various types of radiation as given by Farrington (1936) is shown as follows.

	Wave-length Å	*Electron volts*
Ultraviolet	3000	4.11
Violet	4000	3.09
Blue-green	5000	2.47
Orange	6000	2.06
Red	7000	1.76
Red	8000	1.54
Infrared	10000	1.23

We know nothing of the sensations which insects experience when they see either colored or white light. We know that many react positively to all test colors when they have no choice and go to the light of shorter wave-length when given a choice of two colors of equal physical intensities. We know that when white light as we see it is split into the various wave lengths from ultraviolet to red, and when insects are allowed to make their selection of these physically equalized wave-lengths—the peak of the response curve takes place in ultraviolet (which is invisible to us) and descends sharply to the wave-lengths that are visible to us. We know also that although some flowers reflect ultraviolet, the great mass of green vegetation reflects little or no ultraviolet. We know that of the total radiation from the sun, five per cent or less lies in the ultraviolet, also that the energy of this part of the spectrum is much greater than that of the longer wave-lengths; that photochemical reactions are produced more often by ultraviolet than by longer wave-lengths.

An insect's reaction to light is influenced by many factors, previous exposure to light, angle of incidence, variations in sensitivity of different parts of the compound eye, position of the iris pigment and the rate of pigment migration in relation to light intensity, temperature, moisture, air currents, chemotropism, its variable physiological state, the stimulation of sense organs other than the eyes, the influence of the central nervous system and the wave-length and intensity of the radiation, to which it is first exposed.

For these reasons a single insect, in many but not all cases, is likely to be an unsatisfactory and discouraging animated photometer. It is more likely than not to behave in a way that is completely mystifying and devoid of any fixed pattern. When the behavior of groups of individuals is studied, it is found that a certain proportion of them react in a more or less identical manner with a fair degree of regularity. For example in some species if 200 individuals are exposed simultaneously to 10 wave-length bands, approximately 50 per cent will go to ultraviolet time after time, but this 50 per cent is not always made up of the same individuals.

Thinking of the effect of light upon insects in terms of wave-length and intensity, and assuming, as it is generally held, that insect behavior to different wave-lengths may be due to photochemical reactions in their visual apparatus induced by wave-length and intensity we have an explanation for most of the varied types of insect reactions to light. Of course, this is speculation, especially in the absence of studies involving light and specific types of visual organs, differences in retinal cells, cell changes, photochemical reactions in pigment cells, and the like.

Light, along with moisture, temperature, humidity, air currents plays its part in stimulating the insect into activity and thence into channels that are within its normal life. Although insects are sensitive to a wide range of wave-lengths and are stimulated most by the shorter ones, if

these shorter wave-lengths were missing from the spectrum, insects apparently would still get along very well, under the influence of a narrowed spectrum, unless they need certain vitamins found in green plants that require radiant energy for their growth, or unless substances vital to the insects are produced under the influence of certain wave-lengths. Although some flower-visiting species may find certain wave-lengths useful in locating food, there are numerous species that seem to have little use for an ability to discriminate between colors, and yet they apparently have such ability. In view of this, it would appear that they might thrive either in an ultraviolet world, or a blue world or a green world or even an orange or red world.

Drosophila, the honeybee, the potato beetle, for example, all have wave-length sensitivity, which is qualitatively similar. One would think that color discrimination might enter into the life of the honeybee, but the utility of such discrimination to *Drosophila* and the potato beetle is hard to imagine, although utility as we consider it should not enter into the discussion. When *Drosophila* has reached a certain physiological state and is ready to leave a gloomy cider barrel—radiation would then play its part in activating the insects and getting them out in the light so that dispersal to other cider barrels would be accomplished with the help of other senses. On the other hand, the potato beetle for all its sensitivity to ultraviolet and other parts of the spectrum would seem to have little occasion to use its color discrimination.

As a group, insects have apparently little need to be able to distinguish colors. In spite of various colored flowers, they are confronted mostly by radiation from the sun and sky, and by the reflection from green foliage which reaches a maximum in the region from 5400 Å to 5600 Å (green-yellow). Nevertheless, their sensitivity to wave-lengths extending from 3650 Å to 7200 Å may make it possible for them to pursue their normal activities in the field regardless of constant fluctuations in the relative energy distribution of that part of the solar spectrum to which they are responsive. As a result, they go about their normal activities and are not unduly influenced by changes in the sunlight to which they are exposed. Extensive work along the line started by Moore (1925) may develop the importance of brightness. After all is said and done, the responses to wave-lengths, either short or long, which we interpret as responses to color, are simply manifestations of the effect of radiant energy (wave-length and intensity) upon living organisms, and although insects may or may not have color sensations, to us they frequently behave as if they do, whether they are benefited thereby or not.—12-18-42.

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Preparation for a Career as a Medical Entomologist

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Instruction in the field of medical entomology in the University of California at Berkeley concerns itself with several groups of students: (1) second year medical students,—lectures with illustrative material as an integral part of the course in Preventive Medicine; (2) graduates in medicine (experienced medical doctors),—lectures and laboratory demonstrations in a course entitled "Medical Parasitology" in a Health Officers' training curriculum; (3) undergraduates, including some graduate students,—a general course in "Medical Entomology" as a part of the curriculum in entomology, also open to qualified students in other biological sciences; and (4) graduate students in training as professional parasitologists,—largely in seminars, research, field experience, and personal guidance.

It is obvious that instruction in this field must be more than a glorified course on household and dooryard pests. It demands a fundamental training in entomology in its wider implications including arthropods in general, particularly the arachnids. This emphasizes the fact that the instructor cannot get along with merely a minimum of training and experience in entomology; he must be a good taxonomist, particularly in the Diptera and in the Acarina; he must be an ecologist and a good insect anatomist; he must know his insects and arachnids in their native habitats; he must be an experimentalist; he must be able to recommend appropriate preventive or control measures. It goes without saying that the medical entomologist must be familiar with the field of public health. This is knowledge which cannot be acquired incidentally by the medical doctor who aspires to teach medical entomology; neither can the entomologist, with his usual training, expect to do this without much additional preparation, as suggested in the following discussion.

At this point we should remind ourselves of the considerable number of infections transmitted to man by arthropods and the numerous pathological conditions such as certain dermatoses, myiases, envenomizations, etc., caused directly by them (Herms 1939). Among the more important diseases of man with which these arthropods are vitally connected are malaria, yellow fever, dengue, African sleeping sickness, Chagas' disease, bubonic plague, typhus, Rocky Mountain spotted fever, Verruga, kala azar, onchocerciasis, and relapsing fever. The instructor must know considerable about these diseases as he will need to discuss them in his teaching. The opportunity to observe patients suffering from these diseases and to have some clinical experience is greatly to be desired. Although he has acquired this knowledge the medical entomologist, of course, will not consider himself qualified to speak as may the medical doctor. If the medical entomologist is truly qualified in his *own* field physicians will consult him in many matters pertaining to arthropodan dermatoses, the various myiases, envenomizations, etc.; and health officers and practicing physicians will consult him in matters pertaining to arthropod-borne infections. By these contacts and experiences his teaching will be greatly enriched.

We get into the habit of saying that mosquitoes, flies, etc., carry diseases. In so doing we fail to focus our attention upon the causal agent, the pathogenic microorganism, as we should. A thorough training in bacteriology and mycology should be standard preparation for the medical entomologist. This will not interfere with the professional bacteriologist who in turn would profit by acquiring a substantial knowledge of medical entomology. Indeed medical entomology is required in the graduate curriculum in medical bacteriology at the University of California. An understanding of problems of mutual interest will materially advance cooperative effort and bring about a more rapid and complete solution of difficult problems. Much knowledge pertaining to arthropod-borne infections has come to us belatedly because a solution of problems in this field cuts across the formal boundary lines of several sciences; entomology has been circumscribed. Scientists have been fearful of criticism if they dared to cut across boundary lines. If progress is to be made the qualified medical entomologist must not be hampered in his work by rigid adherence to formal departmental bound-

aries. Since medical entomology must be recognized as one of the parts of the field of parasitology (indeed the most important part), those working as medical entomologists must perforce be well trained in helminthology and protozoology, the two other parts of the field of parasitology. The medical entomologist is therefore a parasitologist in the true sense (Herms 1942).

No matter what group of students are being taught, lectures, laboratory exercises, and demonstrations should more or less fully cover the following concepts depending upon the time available and the academic maturity and experience of the individual students.

No intelligent person will any longer question the importance of arthropods in the field of public health and sanitation. The reader has already been reminded of the large number of arthropod-borne diseases of man, and there are many more affecting animals with which insects and arachnids are vitally connected. Knowledge adequate to cope intelligently with such diseases cannot be acquired in a perfunctory manner. We are dealing with the science of medical entomology (Herms 1909), a science which has tremendous ramifications, as we have already observed and as will be further pointed out. There are no doubt well over a million and a half species of arthropods each with a widely different ecological pattern. Numerous arthropodan species comprise several races; *e.g.*, *Anopheles maculipennis* comprises no less than ten races each differing from the other in breeding and feeding habits, therefore having different relations to malaria transmission. Taxonomic differences are often very difficult to detect; in some instances they are only detectable in egg characters. A matter of first importance to the medical entomologist and a matter to be stressed in instruction is *accurate identification* of the species and its races if these exist.

Arthropods are an important and abundant part of man's environment and it is no wonder that man's life is profoundly influenced by these ubiquitous creatures. Ecology, therefore, is important in the elucidation of epidemiological and control problems in which insects are factors. For example, malaria manifests peculiar phenomena which can be explained only on an ecological basis; *i.e.*, the malaria incidence curve in California (when we had enough malaria to plot curves) showed a peculiar saddleback, a rise in late May to a short peak in June then an abrupt dip toward the latter part of July continuing well toward the middle of August when the curve quickly rose to a very high peak toward the end of September, dropping again in late October. The curve has other interesting characteristics but the description just given will serve our purpose. Freeborn (1932) has shown that humidity profoundly influences the length of life of adult *Anopheles maculipennis*. A relative humidity of 55 per cent and a constant temperature of 070° F. will insure a full average life span of one month. When the humidity drops and the temperature rises in the great central valleys of California the life span of indigenous anophelines shortens so that by mid-July the anopheline females live only long enough to propagate but not long enough for the malaria plasmodia to reach the sporozoite stage in the salivary glands of the mosquito; hence there can be no transmission. When the humidity begins to rise toward the end of summer the anopheline population builds up rapidly and the life span reaches a greater length. The malaria curve at this time rises to a very high peak only to be depressed when cooler weather with lowering temperatures and other ecological factors play a leading rôle in influencing the life of the mosquito or the plasmodium. Thus also can the rarer quartan malaria exist only when the anopheline vector enjoys optimum ecological conditions permitting a life span long enough, *i.e.*, about thirty days, for *Plasmodium malariae* to reach the sporozoite stage in the salivary glands of the mosquito. An anopheline life span of ten days to two weeks is long enough for *Plasmodium vivax* but even that short span is not permitted for a short interval during the summer in California, as already explained.

Not only are we deeply concerned with ecological factors affecting the mosquito vector and the pathogenic microorganism but also with the behavior and habits of man himself; therefore, we have three widely separated species of animals involved in the disease complex we call malaria. The medical entomologist must not lose sight of the host-parasite complex. He must truly be a parasitologist

(Smith 1934). This host-parasite relationship becomes even more complicated in endemic relapsing fever in which a vertebrate reservoir animal is interjected. Here we have a chipmunk (or other suitable reservoir animal), the spirochete, a suitable tick vector, and man—*four* species of organisms involved in the disease we call endemic relapsing fever.

Earlier in this discussion it was implied that medical entomology is an experimental science. How do we arrive at the definite conclusion that certain infections are transmitted by certain arthropods? The process of scientific experimentation (Herms 1929) is a recognized procedure for testing theories and "hunches," but who shall do the experimental work in the field under consideration? To the writer the answer is clear, the person who knows the arthropod best; and this does not merely mean specimens mounted on pins in a laboratory. Unless one is acquainted with the living, feeding, breeding arthropod he is not qualified to instruct in this field, or to use its methods in the solution of parasitological problems. Laboratory colonies are essential; and it is usually necessary to maintain a colony of anopheline mosquitoes, a colony of fleas, or a colony of ticks for use the year around. It is taken for granted that the medical entomologist is familiar with the handling of experimental animals such as mice, guinea pigs, monkeys, birds, and wild rodents. Having accomplished successful transmissions in laboratory animals, in many instances one must still prove transmission in man. Unless this is done accidentally the sympathetic help of a physician, probably one connected with an institution, is needed and one will soon realize, as stated earlier in this paper, how important it is for men working in different but related fields to work together. There is still one important step to take, namely, one must find vectors infected under field conditions in order to prove his point.

Simple transmission tests and demonstrations should be conducted in the laboratory to familiarize the student with techniques and methods of handling the arthropod vectors as well as handling laboratory animals. In the laboratories of the University of California we have found that tick vectors of relapsing fever are easily infected by feeding them on white mice. In successful transmission the time factor is short, about five days, and the spirochetes are easily recovered from the ticks and demonstrated to the students. This is the type of experiment which may be used for laboratory demonstration of transmission.

An important part of instruction will be concerned with the *mechanism of infection*, the way in which the pathogen is acquired by the arthropod, the course and time required before the infected arthropod becomes infectious, and the manner in which the pathogen leaves the body of its arthropodan host and gains entrance into its next host, *i.e.*, a human being, who, as a result of the infection, may suffer disease. Thus the gamut runs from the simple, almost mechanical, inoculation of anthrax bacilli by means of a horsefly to the complicated cyclicopropagative process involved in the successful transmission of the plasmodia of malaria by the bite of an anopheline mosquito.

The mechanism of infection in bubonic plague is still different. Here the appropriate rodent flea picks up the pathogen, *Pasteurella pestis*, from the rodent reservoir, ingesting it with the blood; a blockage of the proventriculus may result from the great multiplication of these organisms and infection follows as a result of regurgitation when the now starved flea attempts to feed on its next victim. Infection may also result when flea feces charged with bacilli are deposited upon the skin and are rubbed in through the excoriated skin. The trypanosome, *Trypanosoma cruzi*, of Chagas' disease is similarly carried to the human skin by feces from the reduviid vector. The virus-laden feces of infected yellow fever mosquitoes may cause fatal infection by the passage of the virus through the pores of the unabraded skin.

Still another mode of infection is the occasional transmission of the Rickettsiae of Rocky Mountain spotted fever by means of crushed ticks. Tick virus is particularly dangerous and great care must be exercised in the removal of ticks to avoid crushing.

Any classification of the ways in which arthropods cause and convery disease must, of necessity, be arbitrary and artificial and the following, which the writer (Herms 1939) has adopted, is no exception:

A. Direct relationships.
   1. Entomophobia,—acute annoyance, hallucinations.
   2. Allergy,—may-fly exuviae, lepidopteran scales, flea bites, etc.
   3. Envenomizations,—black widow spider bite, scorpion sting, etc.
   4. Dermatoses,—sarcoptic scariasis, tropical rat mite, brown tail rash, etc.
   5. Myiasis,—maggot invasions (cutaneous, gastric, etc.)
   6. Accidental injury to sense organs,—invasions by various species of insects, ear ticks, etc.
   7. Tick paralysis,—Rocky Mountain wood tick and others.

B. As vectors of pathogenic organisms.
   1. Accidental carriers.
      a. Food, milk and water contaminators,—flies, cockroaches.
      b. Wound infections,—flies.
      c. Eye infections,—*Hippelates* flies.
      d. Yaws,—*Hippelates* flies.
      e. Simple inoculators,—horseflies, stableflies (dog flies).
   2. Obligatory vectors.
      a. Cyclico-developmental,—filarial worms in mosquitoes.
      b. Cyclico-propagative,—malaria *Plasmodia* in mosquitoes.
      c. Propagative,—Rickettsial infections in lice and ticks; plague bacilli in fleas.

In the presentation of subject matter pertaining to the ways in which arthropods cause and carry disease one may conveniently take up first the direct relationships, considering the arthropods as causal agents in producing allergy, dermatoses, envenomizations, etc. (see above), then group the infections transmitted, either contaminative, cyclical, or propagative, as (1) *bacterial*, such as cholera, plague and tularaemia; (2) *protozoal*, *e.g.*, malaria and African sleeping sickness; (3) *helminthic*, *e.g.*, filariasis and onchocerciasis; (4) *spirochaetal*, *e.g.*, relapsing fever (epidemic and endemic); (5) *rickettsial*, *e.g.*, typhus, Rocky Mountain spotted fever; (6) *viroses*, *e.g.*, yellow fever and dengue.

The difficulty in presenting the subject matter in this way is that there will be much skipping about among the various orders and families of insects and arachnids. Therefore, we will probably prefer to follow the usual entomological procedure of taking up the whole matter by orders; and if we are old-fashioned we will begin with the so-called minor orders which will, incidentally, enable us to call attention to the necessity of the wide knowledge of insects which the medical entomologist must have in order to answer a multitude of questions, such as, What is it? Does it bite? Does it carry disease? Is it poisonous? Where does it come from? Will it poison the drinking water? Students must be advised that they must be first-class entomologists with a substantial background of invertebrate zoology.

In pursuing laboratory instruction no doubt the usual procedure will be followed, *i.e.*, taking up the orders of insects in sequence, ending up with the arachnids. This will be done in the course in medical entomology with lectures and laboratory exercises in the regular entomological curriculum. If one is lecturing to medical students or prospective health officers, he will probably use only selected material for demonstration, as the limited time available will not allow extended laboratory exercises.

In undertaking a consideration of the prevention and control of these offending arthropods (which is after all our aim) let us not lightly stress this "insect menace" that threatens man. As Dr. L. O. Howard has so nicely stated in his "Insect Menace" (Howard 1931), these insects have existed upon the earth some 40,000,000 years, while man has had an existence of hardly more than 400,000 years; hence, with 300,000,000 generations of insects (an average of 8 generations each year) and only 24,000 generations of human beings, insects have had 12,500 times the chance that man has had to evolve a persistent type. Insects are a worthy foe and just a few lessons on how to control them will hardly suffice.

The importance of knowing species (and races) must be emphasized if we are to make our control operations ration, effective, and economical. In this we are concerned with *species sanitation*. This concept implies that the control measures must fit the particular offending species. In any malarial area only one or at most two or three of the local species of anophelines are effective vectors for various reasons (Herms & Gray 1940). In California if malaria control has meant anopheline mosquito control the task would, indeed, have been hopeless, as so many stated, because of the widespread breeding areas; but fortunately of the three species present only one, *Anopheles maculipennis freeborni*, proved to be important and its source was principally seep-

age water from irrigation ditches, a correctable situation. However, if without knowing the specific breeding habits of this species, we had applied the corrective procedures employed for the important malaria vector of the eastern United States, *Anopheles quadrimaculatus*, which breeds principally in impounded water, we would have wasted our money and, of course, would not have reduced our malaria incidence one whit. This is a good example of species sanitation. We should also stress the importance of what is known as *naturalistic control*, recently emphasized by Hackett and his associates (1938) in the Bulletin of the Health Organization of the League of Nations who point out that every species of mosquito is restricted to certain types of surface water in which it alone can breed in effective numbers. The late Dr. H. R. Carter of the U. S. Public Health Service was apparently the first, as early as 1914, to record the beneficial effect of the variation of water level as an anti-larval-mosquito measure. He pointed out that such "changes of elevation within a shorter time than the cycle of development of the mosquito should tend to prevent breeding." Therefore, a good definition for *naturalistic control* is "an imitation of natural processes that results in reduction of a species." Fluctuation of water level is being used by the Tennessee Valley Authority as an important measure in the control of *Anopheles quadrimaculatus* in reservoirs along the Tennessee River.

Training professional medical entomologists involves in great detail all that has been discussed in the previous pages and much more. The proper training of medical entomologists is made all the more urgent in these times of national emergency. At the University of California a minimum of three years of graduate work is necessary. The completion of the undergraduate curriculum in entomology is required, which, in addition to the courses in systematic entomology, insect morphology and histology, ecology, and a summer field course, includes bacteriology, pathology, physiology, nutrition, physics, chemistry, botany, zoology, and genetics. During the postgraduate years the student must take work in advanced bacteriology, protozoology, and helminthology and pass a series of written comprehensive examinations in the following subjects: systematic entomology, insect physiology, insect morphology, insect ecology, insect toxicology, history of entomology, biological control, medical entomology, agricultural entomology, insect-borne plant diseases, and apiculture. Courses in vertebrate zoology (stressing rodents), human anatomy, and hematology are considered essential. Practical field experience must be provided. Examinations in German and French are required. Then follows an oral qualifying examination before the student can be advanced to candidacy. Research work for the dissertation is usually begun during the first year of graduate work. Much stress is placed upon knowledge of current literature (foreign and domestic) pertaining to our field of study. Research work of importance to students preparing for professional service is published in a wide variety of journals many of which are medical and are available only in the library of a Medical School. Too many of us rely upon what we learned from books yesterday. Medical entomology is a rapidly moving subject,—almost daily we learn of new advances along this line which may modify sanitary procedures. On successful completion of all requirements the Ph.D. degree in entomology (medical entomology and parasitology) is awarded.—11-17-42.

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Tests of Fly Repellents of Known Ingredients and of Selected Commerical Sprays on Dairy Cattle[1,2]

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The fly spray business has grown into an enormous industry. Fly spray no longer is sold primarily as a minor item along with various tonics for livestock. A few years ago most of the spray was sold in quart cans, and the brands were numerous. Now many of the largest corporations in America manufacture fly spray. Such a product must have a great future to command such attention, and the integrity of the large corporations selling the product is guarantee enough that a sincere effort is being made to produce a product that has merit and will result in repeat orders. Likewise, the extensive use of well-known brands of fly spray by thousands of leading livestock men throughout America speaks louder than statistics for the future of the industry.

Dairymen probably use more fly spray, certainly of the repellent type, than any other class of purchasers. The problems of sanitary milk production, together with the more detailed handling of dairy cows, has brought this about. The dairyman not only desires a spray that will protect the cows during the milking process for the comfort of both the cow and the attendant, but he also wants a spray that will provide considerable protection throughout much of the day with no ill effects on the skin or general condition of the animals.

Most of the leading manufacturers have at their command chemical staffs which are working toward the perfection of their products. All are alert to any new developments which may come from the agricultural experiment stations or other sources. The research work published has varied from rather simple, poorly controlled trials to carefully planned fundamental research. Although the controlled laboratory tests have been of inestimable value, perhaps too little of the research has been done under carefully planned field conditions.

Literature.—Published reports on experiments designed to measure the efficacy of fly repellents date back at least to 1889 (Smith). Graybill (1914) reviewed the literature on this subject up to that time. Although most of the reports consisted primarily of suggested formulae for fly repellents, a few included observations on repellent action and effect on the animals. In the same publication Graybill reported on the efficacy of various combinations of several constituents. Although many of the materials which he used, and also the large quantities applied per animal, are not in agreement with present day practice the results undoubtedly contributed to the development of modern fly sprays. Later, Cory (1917) reported on the use of pine tar creosote in an emulsion of water and caustic soda. Still later Cory (1928) compared emulsions of pine oil at different concentrations with pine oil emulsion fortified with a pyrethrum-oil spray. He found the pine oil emulsions relatively ineffective as repellents, but that they appeared to have special value as a vehicle for more toxic materials. Baer (1926) commented briefly on a comparison of two commercial fly sprays as repellents for use on dairy cows. Cleveland (1926) reported on a comparison of several sprays, but results were based on casual observations when used by dairymen. Pearson *et al.* (1933) concluded that staking cows individually and making hourly fly counts was more satisfactory than gross observations on larger numbers of cows under typical herd conditions. A complete review of techniques in testing fly sprays was reported by Nelson (1941) as chairman of the committee on cattle sprays of the National Association of Insecticide and Disinfectant Manufacturers. The committee reported the need for field tests but did not approve any specific field

[1] This publication is a report on some phases of a cooperative investigation supported by the establishment of a fellowship at the Kansas Agricultural Experiment Station, June 1940, by the Hercules Powder Company, Wilmington, Delaware. Associated in the general outline and supervision of the investigation were Friar M. Thompson, Jr., Entomologist, Hercules Powder Company and Roger C. Smith, Entomologist, F. W. Atkeson and A. O. Shaw, Dairy Husbandmen, Kansas Agricultural Experiment Station. Graduate Assistants appointed to this fellowship were Floyd J. Holmes, Department of Entomology in 1940, and A. Russell Borgmann, Department of Dairy Husbandry in 1941.

[2] Contribution No. 142 from the Department of Dairy Husbandry, and No. 509 from the Department of Entomology.

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method. More papers have been published on refinement of techniques in recent years than on measurement of repellency of different materials.

In fact, the paucity of published data during recent years on the relative repellence of known materials is rather surprising. Fitch & Lush (1926, 1928) compared four commercial sprays and a home made spray during the fly season of 1924, and two commercial sprays during 1925. They concluded that all sprays were effective and about equal for the first 1.5 hours after spraying. Eight hours after spraying the sprayed animals had fewer flies on them than those not sprayed. Freeborn & Regan (1932) reported on the repellent effect of mixtures of known quantities of pyrethrum or pyrethrum and pine oil in oils of known viscosity and unsulphonated residue content. Pine oil added to the effectiveness of the pyrethrum-oil mixtures, they concluded, and the heavier bodied oils were superior, but oils containing sulphonated residues or unsaturates might be injurious to cows. Pearson's (1935) experiments represent the most extensive carefully controlled work which has been directed primarily toward measurement of repellency of materials of known composition. He used a uniform base oil with and without various quantities of pine oil, pyrethrum, derris, aliphatic thiocyanate, and combinations thereof. He concluded that pine oil increased the repellency of pyrethrum extract or of derris, and that pine oil did not affect the repellent effect of aliphatic thiocyanate.

Although several papers have been published on the effect of fly sprays on milk production and on the physiological reaction of cows, no other reports pertinent to the subject of this paper have come to the attention of the authors.

EXPERIMENTAL.—Field experiments on the efficacy of various fly spray constituents, combinations of them, and some commercial sprays were conducted at the Kansas Agricultural Experiment Station during 1940 and 1941. Since different procedures were used, the procedure involved will be described previous to discussion of results of each series of trials.

Sixteen cows were used in each of the three series of trials conducted in 1940. The relative fly susceptibility of each cow was determined by a preliminary trial of 4 days. The cows were then divided into groups of four each, the groups being balanced according to breed, average daily milk production and fly susceptibility, and were numbered 1, 2, 3, and 4. During the first 4 days Group 1 was unsprayed and served as a check while Groups 2, 3, and 4 were sprayed with selected materials, thereby making possible a comparison of three sprays with check. At the end of each 4-day period, the groups were rotated in numerical order, Group 2 becoming the check group, Group 3 being sprayed with the material previously used on Group 2, Group 4 being sprayed with that previously used on Group 3, and Group 1 taking the previous place of Group 4. At the conclusion of the second 4-day period, the groups were shifted again in numerical order, and the same was done on the fourth 4-day period. Under this "round robin" system covering 16 days, all 16 cows were used as checks for a 4-day period, and likewise were sprayed for 4 days with each of the three sprays being studied.

The cows used in 1940 were all milked three times daily, in the barn at 2:30 to 4:30 A.M., 10:30 A.M. to 12:30 P.M. and 6:30 to 8:30 P.M. Spraying of the animals was begun at 6:30 A.M. and fly counting was begun at 7:00 A.M. Hourly fly counts were made until 10:00 A.M. when the cows were brought in to be milked. The cows were sprayed again at 1:00 P.M. and four hourly fly counts were made, beginning at 1:30. The cows were always sprayed, and the flies counted, in the same order. Spray was applied as uniformly as possible over the entire body with a small electric sprayer, using 25 cc. of spray per cow. The cows were washed at the conclusion of each 4-day period, before being used either as a check group or for study of a different spray material. The cows were staked individually in the same pasture, without shade, while being observed for fly numbers. In general, the procedures in 1941 were the same as in 1940 except that the cows used were milked twice daily, the cows were sprayed only in the morning, and hourly fly counts were continued from 7:00 A.M. until 3:00 P.M.

STATISTICAL ANALYSIS OF DATA.—When the data obtained in the summers of 1940 and 1941 were studied, it became apparent that within sprays, within groups of cows, or within hours, the distributions of fly numbers were quite defi-

nitely skewed. While the majority of the counts per cow per hour fell below 25, enough of the counts were greater than 25, with some ranging on up into the hundreds, to make the arithmetic mean a misleading measure of the typical count for a given classification. Moreover, proper measures of variability could not be obtained.

Entomologists and dairy husbandmen would prefer to see the results of the experiments presented in terms of actual fly counts. This is not possible with data such as fly counts, without the hazard of having tables incorrectly interpreted. Examples of mean counts of 30 flies with one spray and 35 with another within the same series have been found, yet the difference was not significant. The fact that fly counts vary widely under the same conditions makes the occasional high or low count have proportionately greater influence on the average counts than is justified. Also the distribution of counts was not normal, the distribution being skewed to the left resulting from a disproportionate number of smaller counts compared with the number of larger counts. Regardless of the value of reading the results in actual fly counts, such procedure is impossible if the true answer is to be presented. Therefore, all data in this paper were transformed to normalize the distribution so that arithmetic means would be dependable and a proper measure of their variation could be obtained. All analyses and comparisons of means in this paper are based on transformed data and any conclusions regarding differences found between various sprays are dependable. Specific transformations used are presented at the bottom of each table representing a series of tests.

Although the initial series were conducted in a systematic manner, all essentially followed latin square designs. Groups of cows, periods of time, and sprays were taken as the rows, columns, and treatments within cell respectively. The 7×7 latin squares used in the last half of the 1941 tests were non-systematic.

The data obtained in the tests described above were studied by means of analyses of variance, and *t*-tests. The data were arranged in two ways in order to obtain more information: (1) in a spray *x* hour classification; and (2) in a latin square arrangement on groups, periods, and sprays. The former grouping showed the way in which the effectiveness of the sprays diminished during the day, and gave an opportunity to describe that trend statistically. The latter grouping—used only on the 7×7 squares—gave the proper error term for spray comparisons.

The proper statistical methods for conducting fly spray tests are yet under investigation. It is believed that the techniques described above are as good as any known.

ACCURACY OF COUNTING.—Accuracy of original data is of fundamental importance. Since flies move about while the count on an individual cow is in progress, and since the fly numbers vary widely between cows and between hourly counts, the accuracy of the counting might be questioned. Comparison of counts obtained simultaneously on the same cows by two operators showed no significant differences, when statistically analyzed. Likewise, an analysis of the relative constancy of fly susceptibility of individual cows, and the accuracy of balancing groups according to fly susceptibility showed no significant differences between groups.

Since the results of both years showed that horn flies, *Haematobia irritans*, are easily repelled by any of the sprays tested, data on stable flies, *Stomoxys calcitrans*, only will be presented to avoid confusion, save time, and show differences between spray materials.

REPELLENCY TRIALS IN 1940.—Only three groups were involved in the first series. Comparisons were made between check (no spray), tap water, and base oil plus 3 per cent of *Thanite*.[1] Base oil[2] alone was used in the beginning but the supply was inadequate to complete the series. The results presented as transformed data, together with differences necessary to be statistically significant are shown in Table 1.

Tap water spray was not better than no spray when the over-all means were

[1] Fenchyl thiocynyl acetate—Patent No. 2209184.

[2] Specifications of *Stanco* base oil used:

Specific Gravity	.8251
Saybolt Viscosity	36 Min. 41 Max.
Pensky Marten Flash	250 Min.
Fire Point	300 Min.
Unsulfonatable Residue	90%
Initial Boiling Point	510° F.
Distillation End Point	600° F.
Saybolt Color	+15 Min.
Acid Test	40+
3 hr. Corrosion Test at 122° F.	Must Pass
Cold Test	30 Max.

Table 1.—The over-all and hourly repellency of tap water and 3 per cent *Thanite*, in base oil. (Transformed data) (June 25–July 13, 1940).

Spray Used	Over-all Mean[1]	Difference from Check	Hourly Means[1] 7 A.M.	8 A.M.	9 A.M.	10 A.M.	Over-all Mean[1]	Difference from Check	Hourly Means[1] 1:30 P.M.	2:30 P.M.	3:30 P.M.	4:30 P.M.
Check—no spray	6.25		5.69	6.30	6.67	6.36	4.90		4.55	5.09	5.07	4.91
Tap water	6.02	0.23	5.29	6.28	6.38	6.13	4.85	0.05	4.41	5.04	5.05	4.89
3 per cent of *Thanite* in base oil	4.30	1.95	2.80	4.19	3.31	5.35	3.54	1.36	3.79	3.38	3.87	4.13

[1] Mean = Mean of the square roots of (individual fly-counts plus 0.5)
Note—Base oil used was colorless, odorless distillate with a viscosity of 40 seconds.

A.M. Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	0.89	0.32
Highly significant difference (odds 1–99)	1.34	0.42

P.M. Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	0.76	0.39
Highly significant difference (odds 1–99)	1.15	0.51

compared statistically. When a mixture of 3 per cent *Thanite* and 97 per cent base oil was applied, the reduction in fly numbers was highly significant at each hourly count during the day, although in both the morning and afternoon sprayings there was a tendency for the differences on the fourth hour to be less than those of the first three hours.

The second series, conducted in the same manner as the first, consisted of a comparison between check, 1 per cent *Thanite* in base oil, 2 per cent *Thanite* in base oil, and 4 per cent *Thanite* in base oil. The results are presented in terms of the transformed data in Table 2.

Applications of *Thanite* in base oil in either 4, 2 or 1 per cent concentrations of *Thanite* caused such reductions in numbers of flies compared with the check that the odds are at least 99:1 that the observed superiority of the sprays was not a chance occurrence. As the concentration of *Thanite* was increased the difference from check became greater. The effectiveness of the spray was in direct relation to the amount of *Thanite* used; the difference between the over-all means for the spray containing 4 per cent *Thanite* and the 1 per cent *Thanite* mixture were highly significant, but the differences between 1 per cent *Thanite* and 2 per cent, or between 2 per cent and 4 per cent were not consistently significant. The effectiveness of the sprays as indicated by the hourly means consistently ranked in the same order as the over-all results for both the morning and afternoon sprayings. After the first two counts (about 1.5 hours after spraying) the effectiveness generally diminished but the differences from check at the end of the fourth hourly count were all highly significant, even when only 1 per cent *Thanite* was used.

Series III consisted of a comparison of check with base oil alone, with 5 per cent of a 20 to 1 concentration of pyrethrum in base oil, and with 5 per cent *Thanite* in

Table 2.—The over-all and hourly repellency of 1, 2 and 3 per cent *Thanite*, in base oil. (Transformed data) (July 17–August 3, 1940).

Spray Used	Over-all Mean[1]	Difference from Check	Hourly Means[1] 7 A.M.	8 A.M.	9 A.M.	10 A.M.	Over-all Mean[1]	Difference from Check	Hourly Means[1] 1:30 P.M.	2:30 P.M.	3:30 P.M.	4:30 P.M.
Check—no spray	5.38		5.18	5.89	5.77	6.09	4.34		3.58	4.37	4.63	4.78
1 per cent *Thanite*, in base oil	4.48	1.35	3.34	4.33	5.04	5.18	3.30	1.04	1.97	2.91	3.96	4.39
2 per cent *Thanite*, in base oil	4.09	1.74	2.62	3.85	4.85	5.05	2.92	1.42	1.61	2.49	3.45	4.12
4 per cent *Thanite*, in base oil	3.65	2.18	2.36	3.38	4.26	4.62	2.35	1.99	1.15	1.87	2.85	3.52

[1] Mean = Mean of the square roots of (individual fly-counts plus 0.5).
Note—Base oil used was colorless, odorless distillate with a viscosity of 40 seconds.

A.M. Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	0.52	0.27
Highly significant difference (odds 1–99)	0.75	0.36

P.M. Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	0.52	0.25
Highly significant difference (odds 1–99)	0.75	0.33

Table 3.—The over-all and hourly repellency of base oil, 5 per cent of 20 to 1 concentrate of pyrethrum, in base oil and 5 per cent *Thanite*, in base oil. (Transformed data) (August 20–September 9, 1940).

Sprays Used	Over-all Mean[1]	Difference from Check	Hourly Means[1] 7 A.M.	8 A.M.	9 A.M.	10 A.M.	Over-all Mean[1]	Difference from Check	Hourly Means[1] 1:30 P.M.	2:30 P.M.	3:30 P.M.	4:30 P.M.
Check—no spray	7.02		5.71	7.33	7.66	7.36	7.06		6.31	7.28	7.67	6.95
Base oil	5.68	1.34	1.97	5.53	6.91	6.95	5.95	1.11	4.30	5.86	6.93	6.73
5 per cent of 20:1 conc. of pyrethrum, in base oil	3.85	3.17	1.98	3.24	4.67	5.49	4.30	2.76	2.53	4.07	5.26	5.35
5 per cent *Thanite*, in base oil	2.78	4.24	1.38	2.34	3.32	4.08	3.14	3.92	1.91	2.92	3.77	5.97

[1] Mean = mean of the square roots of (individual fly-counts plus 0.5).
Note—Base oil used was colorless, odorless distillate with a viscosity of 40 seconds.

A.M. Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	0.86	0.24
Highly significant difference (odds 1–99)	1.24	0.32

P.M. Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	1.70	0.20
Highly significant difference (odds 1–99)	2.45	0.26

base oil (Table 3). The over-all means showed that base oil alone was definitely effective as a repellent in the morning trials, but that the apparent superiority over check in afternoon trials might well have been a chance occurrence. Most of the effect from base oil alone was obtained at the first count (about 30 minutes after spraying), particularly in the morning trials, but its effect was rapidly lost. The mixture of pyrethrum (5 per cent of 20 to 1 concentrate in base oil) reduced the numbers of flies on the cows to a highly significant degree as shown by the over-all means for check and pyrethrum. This was true for both morning and afternoon sprayings. Comparison of the over-all means of the pyrethrum mixture and the over-all means of base oil showed highly significant differences in the morning sprayings but not quite minimal significant differences in the afternoon sprayings. The *Thanite* (5 per cent) mixture apparently had the highest efficiency of any of the materials used in the series. *Thanite's* observed superiority over check and base oil was statistically highly significant throughout both morning and afternoon. However, the amount by which the fly counts for *Thanite* were below those for pyrethrum was only significant during the mornings; the observed difference in the afternoons might reasonably have been the product of experimental variation.

All sprays studied decreased in effectiveness as time passed, but the *Thanite*

Table 4.—The over-all and hourly repellency of 3 per cent *Thanite*, in base oil, 2.5 per cent of 20 to 1 concentrate of pyrethrum plus 15 per cent *Yarmor* pine oil, in base oil, 3.75 per cent of 20 to 1 concentrate of pyrethrum plus 10 per cent *Yarmor* pine oil, in base oil. (Transformed data) Series I (June 16–June 31, 1941).

Sprays Used	Over-all Mean[1]	Difference from Check	Hourly Means[1] 7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 Noon	1 P.M.	2 P.M.	3 P.M.
Check—no spray	6.51		5.62	6.83	7.67	7.30	6.60	6.10	5.96	5.97	6.57
3 per cent *Thanite*, in base oil	4.03	2.48	2.04	2.83	4.30	4.36	4.27	3.96	4.31	5.01	5.24
2.5 per cent of 20:1 conc. of pyrethrum plus 15 per cent *Yarmor* pine oil, in base oil	3.52	2.99	1.84	2.51	3.50	4.07	3.68	3.31	3.83	3.98	4.97
3.75 per cent of 20:1 conc. of pyrethrum plus 10 per cent *Yarmor* pine oil, in base oil	3.31	3.20	1.94	2.28	3.23	3.67	3.76	3.18	3.63	3.74	4.38

[1] Mean = mean of the square roots of (individual fly-counts plus 0.5).
Note—Base oil used was colorless, odorless distillate with a viscosity of 40 seconds.

Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	0.50	0.73
Highly significant difference (odds 1–99)	0.68	0.95

mixture lost its effectiveness on the average less rapidly than did the others.

REPELLENCY TRIALS IN 1941.—Series I and II in 1941 were conducted by the same round robin method as described for the 1940 series. The first series consisted of a comparison of check, 3 per cent *Thanite* in base oil, 2.5 per cent of a 20 to 1 concentration of pyrethrum plus 15 per cent *Yarmor* pine oil in base oil, and 3.75 per cent of a 20 to 1 concentration of pyrethrum plus 10 per cent *Yarmor* pine oil (Table 4).

All three sprays were found from statistical analysis to be highly effective when compared with check (Table 4). The most effective spray was the pyrethrum mixture composed of 3.75 per cent of 20 to 1 concentrate of pyrethrum plus 10 per cent of *Yarmor* pine oil. The other pyrethrum mixture (2.5 per cent pyrethrum concentrate 20 to 1 plus 15 per cent *Yarmor* pine oil) was second. *Thanite* (3 per cent) in base oil ranked third. The difference between the over-all means of the two pyrethrum mixtures was well within the bounds of sampling variation; but fly counts on cows sprayed with the 2.5 per cent pyrethrum mixture were enough lower than similar counts for the *Thanite* mixture that the chances of this being a chance event are about 1 to 19. The 3.75 per cent pyrethrum mixture, however, showed a highly significant difference from the *Thanite* mixture.

Study of the hourly means shows that the effectiveness of each of the sprays diminished as time from spraying increased. Much higher repellence was obtained during the first and second (1.5 hours) fly counts than on later hourly counts. Much of the difference in over-all means is due to the first two counts because after the third hourly fly count (2.5 hours) until the seventh count (6.5 hours) the three sprays remained about the same in effectiveness. On the ninth hourly fly count the differences between check and each of the sprays were still highly significant. These facts lend encouragement to the hope of developing fly sprays that will be noticeably effective from one milking until another, but they also raise the question of how completely cows can be protected from flies by spraying.

Table 5.—The over-all and hourly repellency of 5 per cent *D.H.S. Activator*, in base oil. 2.5 per cent of 20 to 1 concentrate of pyrethrum, in base oil, and 3 per cent *Thanite* in base oil. (Transformed data) Series II (July 1–July 28, 1941).

Sprays Used	Over-all Mean[1]	Difference from Check	Hourly Means[1]								
			7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 Noon	1 P.M.	2 P.M.	3 P.M.
Check—no spray	6.71		5.54	6.04	6.54	7.26	7.16	6.62	6.96	7.37	6.97
5 per cent of *D.H.S. Activator* in base oil	6.73	0.02	5.09	5.85	6.72	7.77	7.34	6.59	7.16	6.91	7.16
2.5 per cent of 20:1 conc. of pyrethrum plus 5 per cent *D.H.S. Activator*, in base oil	5.92	0.79	3.26	4.33	5.95	6.13	6.16	6.22	6.84	6.80	7.08
3 per cent *Thanite*, in base oil	5.79	0.92	3.56	4.33	5.42	5.93	6.64	6.05	6.60	6.53	7.05

[1] Mean = mean of the square roots of (individual fly-counts plus 0.5).
Note—Base oil used was colorless, odorless distillate with a viscosity of 40 seconds.

Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	0.40	0.86
Highly significant difference (odds 1–99)	0.50	1.13

Series II in 1941 consisted of a comparison of check, 5 per cent *D.H.S. Activator*[1] in base oil, 2.5 per cent of 20 to 1 concentration of pyrethrum plus 5 per cent *D.H.S. Activator* in base oil, and 3 per cent *Thanite* in base oil (Table 5). The purposes of these comparisons were to determine whether *D.H.S. Activator* alone had any effect on repellence, and whether the pyrethrum mixture when fortified with 5 per cent of the *Activator* would be more effective than a 3 per cent *Thanite* base oil mixture.

Study of the over-all means shows that the *D.H.S. Activator* in base oil was not superior to the unsprayed group. This is

[1] Ethylene Glycol Ether of Pinene—Reg. U. S. Pat. Off. by Hercules Powder Company. Patent Nos. 2,136,011; 2,160,579.

further emphasized in the data on hourly fly counts. Statistical analysis of the over-all means showed that pyrethrum mixture plus *D.H.S. Activator* and the *Thanite* spray both reduced fly numbers to a highly significant degree as compared to check. The *Thanite* mixture and the pyrethrum mixture did not differ significantly in repellency. In an hourly analysis of the pyrethrum mixture, the data did not show a significant difference from check beyond the second count (1.5 hours), while the results on the *Thanite* mixture showed significant repellence until the fourth fly count (3.5 hours). In this series the repellent effect of the sprays lasted less than half as long as in the previous series.

In series III and IV during 1941 the same general procedure was used but randomized latin squares replaced the systematic squares previously used. Seven groups were used and each group contained three cows instead of four as in a previous series. The procedure also differed from previous series in that 30 cc. of spray was used instead of 25 cc.

Series III represented the following comparisons:

1. Check (no spray).
2. 2.5 per cent of 20 to 1 concentrate of pyrethrum in base oil.
3. 2.5 per cent of 20 to 1 concentrate of pyrethrum plus 5 per cent *D. H. S. Activator* in base oil.
4. 2.5 per cent of 20 to 1 concentrate of pyrethrum plus 15 per cent *Yarmor* pine oil in base oil.
5. 5 per cent of 20 to 1 concentrate of pyrethrum, in base oil.
6. 3 per cent *Thanite* in base oil.
7. 5 per cent *Thanite* in base oil.

This series represents an effort to bring together in one trial most of the combinations of spray materials previously studied. The results are shown as transformed data in Table 6. Comparison of the over-all means shows highly significant differences between check and each of the sprayer materials studied. When the mixture of 2.5 per cent of 20 to 1 concentrate pyrethrum in base oil is compared with the same mixture plus 5 per cent *D.H.S. Activator*, the over-all mean is found to be a little greater for the mixture containing the activator but the difference is not significant. Likewise it was found that the addition of 15 per cent *Yarmor* pine oil to the original pyrethrum mixture did not result in a significant change in repellence. Although the mixture containing *Yarmor* pine oil showed a greater average difference from check than either of the other pyrethrum mixtures, this difference is well within the limits of experimental error.

The difference between the over-all means for 2.5 per cent pyrethrum in base oil and the same mixture containing 5 per cent pyrethrum was of minimal significance, indicating that the additional pyrethrum increased the effectiveness of the spray. Whether the increased effectiveness is enough to justify doubling the amount

Table 6.—The over-all repellency of sprays of known composition. (Transformed data) Series III (August 15–September 7, 1941).

Sprays Used	Over-all Mean[1]	Difference from Check	Hourly Means[1] 7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 Noon	1 P.M.	2 P.M.
Check—no spray	.139		.153	.132	.133	.128	.137	.147	.142	.138
2.5 per cent of 20:1 conc. of pyrethrum in base oil	.200	.061	.267	.234	.205	.184	.183	.184	.176	.164
2.5 per cent of 20:1 conc. of pyrethrum plus 5 per cent *D.H.S. Activator*, in base oil	.201	.062	.260	.235	.206	.190	.189	.187	.176	.166
2.5 per cent of 20:1 conc. of pyrethrum plus 15 per cent *Yarmor* pine oil in base oil	.204	.065	.266	.234	.213	.188	.191	.190	.177	.175
5 per cent of 20:1 conc. of pyrethrum in base oil	.210	.071	.274	.247	.222	.196	.201	.198	.178	.165
3 per cent of *Thanite* in base oil	.218	.079	.276	.253	.231	.204	.209	.209	.188	.177
5 per cent of *Thanite* in base oil	.222	.083	.276	.260	.235	.218	.213	.212	.184	.176

[1] Mean = mean of (one, divided by the square root of individual fly-counts plus 10)
Note—Base oil used was colorless, odorless distillate with a viscosity of 40 seconds.

Significant Difference	Over-all	Hourly
Minimal significant difference (odds 1–19)	.009	.018
Highly significant difference (odds 1–99)	.012	.024

of pyrethrum used is, as yet, a question.

The results obtained with the mixture of 3 per cent *Thanite* in base oil were better than the results obtained with any of the previously mentioned sprays in this series. The over-all difference between this mixture and the mixture containing 5 per cent of a 20 to 1 concentrate of pyrethrum was just significant. The 3 per cent

Series IV in 1941 represented a comparison of several commercial sprays with a recommended home-made spray, and with 3 per cent *Thanite* in base oil. The object of this series was to evaluate the *Thanite* mixture, which had proved more satisfactory than most other mixtures, in terms of some accepted sprays. In other words, how good is a good spray? The

Table 7.—The over-all and hourly repellency of four commercial sprays compared with two sprays of known composition. (Transformed data) Series IV (August 7–14, September 8–23).

Sprays Used	Over-all Mean[1]	Difference from Check	Hourly Means[1]							
			7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 Noon	1 P.M.	2 P.M.
Check—no spray	.169		.187	.169	.168	.160	.167	.172	.166	.163
Commercial spray No. 1	.206	.037	.271	.235	.205	.193	.189	.191	.182	.180
Commercial spray No. 2	.209	.040	.280	.246	.214	.196	.186	.190	.183	.177
Commercial spray No. 3	.212	.043	.265	.243	.216	.203	.196	.194	.188	.188
Commercial spray No. 4	.215	.046	.279	.249	.227	.201	.193	.194	.194	.181
U.S.D.A. (1) in fish oil	.220	.051	.287	.255	.234	.209	.197	.197	.194	.186
3% *Thanite*, in base oil	.225	.056	.287	.267	.247	.218	.203	.204	.194	.178

[1] Means = mean of (1 divided by square root of individual fly-counts plus 10).
Note—Base oil used was a colorless, odorless, white distillate with a viscosity of 40 seconds.
(1) U. S. Dept. Agr. Farmers Bulletin No. 1097.

Significant Differences	Over-all	Hourly
Minimal significant difference (odds 1–19)	.009	.024
Highly significant difference (odds 1–99)	.012	.032

Thanite mixture was superior to any of the other spray mixtures previously mentioned as indicated by highly significant differences between the over-all means.

The mixture containing 5 per cent *Thanite* produced the lowest over-all mean fly-count when compared with any of the other five spray mixtures. In fact, differences were highly significant compared with all other sprays, except the 3 per cent *Thanite* mixture. The difference between the 3 per cent and 5 per cent *Thanite* mixtures was not significant.

Study of the hourly means shows the same relative results for the sprays used as did the over-all means. All of the sprays showed highly significant differences from check at the eighth hourly fly-count (7.5 hours after spraying). This indicates longer effect than is commonly believed.

The sprays did not differ greatly in the hold-over effectiveness from hour to hour. There does seem to be a minimal significant over-all effect caused by the addition of *D.H.S. Activator* to the pyrethrum mixture. The same is true for the addition of *Yarmor* pine oil. The *Thanite* mixtures had more hold-over effect than any of the other sprays.

supply of each commercial spray was purchased on the open market in sealed cans. The comparisons made were as follows:

Check—no spray
Spray No. 1
Spray No. 2
Spray No. 3
Spray No. 4
U. S. Dept. Agr. mixture in fish oil.
Thanite 3 per cent, in base oil.

Statistical analysis of the data from this series showed: (1) All the sprays tested reduced the fly-counts so far below check that there is no reasonable doubt of their repellency. (2) *Thanite* was observed to be the most repellent spray tested but its superiority over the U. S. Department of Agriculture spray was statistically non-significant. (3) The U. S. Department of Agriculture spray was definitely more repellent than sprays Nos. 1 and 2; but its apparent superiority to sprays Nos. 3 and 4 might reasonably have been the result of sampling variation. (4) While spray No. 4 is probably more repellent than No. 1, the commercial sprays were of much the same quality as repellents over the whole day. These con-

clusions are verified by data in table 7.

Certain outstanding differences were noticeable in the lasting qualities of the different sprays. Only two of the sprays differed from check significantly at the sixth hourly fly-count. At the eighth hourly count, only one commercial spray, among all the sprays, was just barely significantly different from check. However, at the seventh hourly count, *Thanite* was still significantly better than check and was as repellent as any of the sprays tested.

SUMMARY AND CONCLUSIONS.—Field experiments on the efficacy of various fly spray constituents, combinations thereof, and some commercial sprays were conducted during 1940 and 1941.

During the three trials in 1940 and the first two trials in 1941 the cows were divided into groups of four cows, the groups being balanced according to fly susceptibility, breed and daily milk production. Spraying periods of four days were used and the groups were rotated in a systematic "round robin" fashion from spray to spray each 4 days until each group had been sprayed with each material and had served as check for 4 days. In the last two trials during 1941 a randomized latin square method of group rotation was used.

Since the distribution of fly numbers was definitely skewed, it was necessary to transform the data before statistical analysis of variance could be used in interpreting differences between sprays.

Accuracy of counting was tested by having two operators count independently at the same time. Statistical analysis showed no significant differences between the counts. Likewise, an analysis of the relative constancy of fly susceptibility of individual cows, and the accuracy of balancing groups showed no significant differences.

Series I in 1940 showed that spraying with tap water was not significantly better than no spray. A mixture of 3 per cent *Thanite* in base oil (viscosity—40 seconds) showed a highly significant difference from check for the over-all means, and the difference by hourly counts was still highly significant at the last hourly count, 4 hours after spraying.

Results of Series II showed mixtures of 1, 2 and 4 per cent *Thanite* in base oil all caused a highly significant reduction in numbers of flies compared with check. The difference between the over-all means for the 4 per cent *Thanite* mixture and the 1 per cent *Thanite* mixture was highly significant, but the differences between the 4 per cent and the 2 per cent mixtures, or between the 2 per cent and the 1 per cent mixtures were not consistently significant. The effectiveness of each spray diminished hourly but all were highly significant in difference from check at the last count, 4 hours after spraying.

In Series III, base oil alone showed a highly significant repellent effect after the morning spraying but a non-significant effect after the afternoon spraying, when compared with the check group. A mixture of 5 per cent of 20 to 1 concentrate of pyrethrum in base oil showed highly significant repellency when the over-all mean was compared with that of check, (and also base oil alone on morning spraying). *Thanite* (5 per cent) in base oil also reduced fly counts to a highly significant degree as compared with either check or base oil; but when the *Thanite* mixture was compared with the pyrethrum mixture, the difference was only of minimal significance in the morning sprayings.

In Series I during 1941 all three sprays were adjudged highly effective after a statistical comparison of their over-all means with those for the check groups. The three sprays ranked as follows: 1st—pyrethrum (3.75 per cent 20 to 1 concentrate) plus 10 per cent *Yarmor* pine oil, 2nd—pyrethrum (2.5 per cent 20 to 1 concentrate) plus 15 per cent *Yarmor* pine oil, and 3rd —*Thanite* (3 per cent) in base oil. The observed difference between the two pyrethrum sprays was not significant. A difference like that observed between the means for the 2.5 per cent pyrethrum spray and the *Thanite* mixture would be produced by sampling variation about once in twenty such trials, while the difference between the 3.75 per cent pyrethrum mixture and *Thanite* mixture should occur by chance not more than once in a hundred trials. All three sprays were of approximately equal value from the third hourly count until the seventh count.

Series II showed that *D.H.S. Activator* alone in base oil was no more effective than no spray. A mixture of pyrethrum (2.5 per cent of 20 to 1 concentrate) plus 5 per cent *D.H.S. Activator* was definitely repellent as compared to check. The same was true for *Thanite* (3 per cent) in base

oil. The difference between the over-all mean of the pyrethrum mixture and the over-all mean of the *Thanite* mixture was not significant, but the pyrethrum mixture was not significantly different from the check group after the first two hourly counts, while the *Thanite* mixture was significantly different for four hourly counts. The repellent effect of the sprays lasted about half as long as in the previous series.

In Series III an attempt was made to bring most of the previous comparisons together in one trial. All six sprays produced highly significant repellence as compared to check. Adding 5 per cent *D.H.S. Activator* to a pyrethrum mixture (2.5 per cent of 20 to 1 concentrate in base oil) did not result in a significant difference from the same mixture without the *D.H.S. Activator*. Likewise, adding 15 per cent *Yarmor* pine oil to the same pyrethrum mixture did not produce more than sampling variation from the effects of the original mixture. Increasing the pyrethrum concentrate to 5 per cent increased the effectiveness of the spray compared with 2.5 per cent mixture.

Thanite (3 per cent in base oil was superior to any of the other sprays as indicated by highly significant differences between the over-all means. Increasing the *Thanite* to 5 per cent increased the effectiveness of the spray. All the sprays showed highly significant differences from check group 7.5 hours after spraying time. *Thanite* had more lasting effect than any of the other sprays.

Series IV consisted of a comparison of *Thanite* (3 per cent) in base oil with four popular commercial brands of fly spray and the home-made mixture recommended by the U. S. Department of Agriculture. The *Thanite* mixture was the most effective spray tested but the difference observed between it and the Department of Agriculture spray was not significant. The difference between *Thanite* and the best commercial spray was beyond reasonable sampling variation.—11-13-42.

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Techniques for Conducting Fly-Repellency Tests on Cattle[1,2,3]

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Many cattle fly sprays have been produced and new ones are being developed but there is as yet no standard technique for testing those sprays critically under actual field conditions (Nelson 1941). This failure to develop a suitable technique has resulted from the many variables encountered in such research, from the type of data which is obtained, and from the fact that statistical methods suitable to this type of experimentation have been lacking until comparatively recently.

Such factors as weather, color of the hair of the cow, hour of day at which counts are taken, and numerous other biological and environmental factors may determine the number of flies found on the cattle in the field. Some of these factors can be controlled, but certain others are either unknown or too complex to be dealt with individually in practice. Hence there are two general types of variation found among fly counts from cattle spray experiments: (1) those non-random variations produced by such factors as breed and time of day at which counts were made; and (2) those random, or experimental, variations arising from cow-to-cow differences in susceptibility to flies, from the idiosyncrasies of flies while feeding, and from numerous intangible differences always found in biological materials.

The investigator deliberately introduces another possible source of non-random variation into an already complex pattern by applying various insecticides which may differ in repellent qualities. Valid information is then sought on the following specific points: (1) How do the insecticides compare as fly repellents? (2) How long after application is each spray effective? (3) How important are certain possible sources of non-random variation, and how can the technique for conducting this type of research be improved? If the experiment is designed in advance so that the data may be interpreted by means of the best statistical methods now available, reliable answers can be given to the questions the research was designed to answer. Another paper (Shaw *et al.*) from the Kansas Agricultural Experiment Station presents such a statistical treatment of data from field tests of several outstanding cattle sprays and one new type.

The purpose of this paper is to clarify and justify some of the newer statistical methods used at this station and to suggest a basis for the development of a standard technique for conducting fly-repellency tests on cattle in the field.

Historical Background.—Survey of the literature indicates a rather general appreciation of the physical and biological factors which may affect comparisons of sprays. Variations in techniques of experimentation have been the result of attempts to obviate such factors. Although fly spray experiments usually yield large masses of data requiring statistical analysis, such analysis has not been employed extensively either to test the validity of conclusions or to determine the relative effectiveness of each technique.

Two general techniques for testing fly sprays under field conditions, the *whole-cow* and the *half-cow* methods, have evolved from the efforts of experimenters to prevent the environmental and biological variants from warping the information obtained. The earlier investigators used a check group and a sprayed group, but fly susceptibility is so complex and changeable that this scheme was abandoned in favor of groups of cows rotated from one spray to another, or to check. Pearson and his colleagues (1933) attempted to assemble groups of cows which, as whole groups, presented about the same attractiveness to flies. If such balanced groups are formed successfully, the same number of flies (within the bounds of reasonable experimental variation) will be attracted to each group of cows, provided the groups are treated alike. Then the relative efficiencies of different sprays can be studied upon the

[1] This publication is a report on some phases of a cooperative investigation supported by a fellowship established at the Kansas Agricultural Experiment Station, June 1940, by the Hercules Powder Company, Wilmington, Delaware. Associated in the outlining and supervising of the investigation were Friar M. Thompson, Jr., Entomologist, Hercules Powder Company, and Roger C. Smith, Entomologist, F. W. Atkeson, and A. O. Shaw, Dairy Husbandmen, Kansas Agricultural Experiment Station. Graduate Assistants appointed to this fellowship were Floyd J. Holmes, Department of Entomology in 1940, and A. Russell Borgmann, Department of Dairy Husbandry in 1941.
[2] Contribution No. 152 from the Department of Dairy Husbandry and No. 518 from the Department of Entomology.
[3] Early publication of this paper has been secured by payment of the costs of printing.
[4] Statistician, Agr. Expt. Station.

basis of the numbers of flies remaining on the groups of cattle after different sprays have been applied. Variations of the *whole-cow* method, such as *one-cow* groups rotated daily, also have been tried.

More recently, the *half-cow* method has been suggested. All factors which influence fly counts are assumed to be controlled by using one half of the cow as a check against the other half. Nevertheless, certain objections to the *half-cow* method have been (Mailen & Fenton 1941; Nelson 1941), or can be, raised. These are: (1) It is usually assumed that the flies which a spray drives from one side of the cow go to the other side. This is questioned. (2) The odors of sprays and the movements of the cow's head and tail may confuse the matter of repellency when two sprays are tested on the same cow. (3) The comparison of two or more sprays has been made either cumbersome or invalid by the use of inadequate statistical techniques. (4) Each experimenter chooses his own formula for the measurement of repellency.

The third and fourth objections could be removed by means of a symmetrical pairs design as will be explained later.

The literature on the testing of cattle fly repellents presents scarcely any data or any statistical analysis. It is seldom apparent how the experimental data have been used to support the conclusions drawn. However, progress is beginning along such lines. Searles & Eisenhart have analyzed their data by the analysis of variance and t-tests after first transforming that data to achieve approximate normality in the distribution of the numbers analyzed. They also used one-cow groups and a system for rotating the cows from one spray to another daily.

Other experimenters (Pearson *et al.* 1933; Pearson 1935) have used the *whole-cow* method and then have confined their statistical analyses to the calculation of arithmetic means and standard deviations. That procedure is not justifiable in view of the distributions followed by fly counts on cattle either with or without previous spraying. It will be shown that the arithmetic mean does not represent a group of such counts well, nor does the standard deviation adequately describe the dispersion about the mean.

McCreary & Goddin (1937) used a *half-cow* method and apparently analyzed percentage data based on counts which are usually well below 100 and quite unequal. It is considered preferable (Snedecor 1940) under such circumstances to use an arcsine transformation as a means of normalizing the data prior to analysis.

The technique of transforming certain entomological data to approximate normality of distribution has been found both necessary and successful in the work at the Kansas Agricultural Experiment Station. However, Upholt (1942) has very recently reported an investigation of the use of the square root transformation which that author feels leaves this statistical procedure open to question. The findings at the Kansas Station do not support those of Upholt, in certain respects, as will be pointed out in a later section.

DESIGNING THE EXPERIMENT.—When it is agreed that a proposed investigation of the qualities of several cattle fly sprays must be planned in advance and made as objective as possible, it is important that the experimental procedure be set up with the following three requirements in mind: (1) The studies to be made of the data must not be vitiated by a failure to take adequate account of the variables involved. (2) The eventual arrival at sound conclusions should be jeopardized to a minimum degree by the present lack of complete knowledge of those forces influencing fly counts on cattle. (3) The manner of conducting the experiment must leave it possible to make unbiased estimates of the sampling variation to which the fly counts will be subject so that the importance of the variations due to different sprays, different breeds, *et cetera*, may be assessed properly.

Statistical techniques have been designed to assist in the fulfillment of the above requirements. Their application starts with the designing of the experimental procedure to be followed and ends with the final analysis and interpretation of the data.

A *whole-cow* method of testing sprays already has been said to require groups of cattle which, as groups, and under the same conditions, attract the same number of flies, within the limits of sampling variation. Also, the range of susceptibilities from cow to cow within each group should be about the same. With such well-balanced groups of cattle, it might seem unnecessary to test every spray on every

cow during the experiment. However, the biological and environmental factors which influence the numbers of flies on cattle are not all known. Moreover, interactions with weather are possible. Hence, it seems better at the present stage of this type of research to employ a statistical design in which all the spray treatments are applied to all the cows in the experiment and in such a manner than the best available statistical analyses may be applied to the data obtained during the investigation.

A latin square design has those features. If six sprays are to be compared along with a check, a 7 by 7 latin square on Groups of Cows and Periods of Time makes it possible to study the comparative repellencies and the lasting qualities of the various sprays used. Basic latin squares can be found in several publications including the Fisher-Yates (1938) tables and Fisher's Design of Experiments (1937). One of the squares employed in the research at the Kansas Agricultural Experiment Station is shown in the accompanying (Fig. 1). The balanced groups of cows were assigned numbers 1 to 7 by a chance drawing of those numbers. The sprays were designated as A, B, C, etc. by a similar scheme of randomization.

	PERIOD						
Group	I	II	III	IV	V	VI	VII
1	C	B	A	D	E	F	G
2	D	A	F	C	B	G	E
3	B	C	D	A	G	E	F
4	E	D	G	F	C	B	A
5	A	E	B	G	F	C	D
6	F	G	E	B	D	A	C
7	G	F	C	E	A	D	B

FIG. 1. A 7x7 latin square

Cochran (Cochran *et al.* 1941) has suggested a latin square design for certain dairy cattle feeding experiments. In that design one cow was used per cell of the square, and several squares were used. If one employed the same number of cows as was used in the square of figure 1, there would be three separately randomized latin squares. Such a design would be more complex to carry out and would be more seriously affected by any loss of animals from the experiment than would the one-square design with three cows per cell. Since the group-to-group variation is made approximately random by balancing the groups, and since the one-square design is simpler to carry out, it was considered preferable for the fly spray tests at this station.

The latin square design is readily analyzed and gives valid information on the relative repellencies of the various sprays, the relative susceptibilities of the groups of cattle employed in the tests, and the changes in fly population and in the susceptibility of cows from one period of time to another. Other important information is also obtainable.

It was stated earlier that the *half-cow* method has not been standardized as regards either the manner of conducting the tests or of using the data to study the relative repellencies of several sprays. Yates (1936) has devised a whole class of "incomplete randomized block" designs including one usually known as a "symmetrical pairs" design. That latter type of design is applicable to situations in which "blocks" are naturally restricted to two experimental units. There appears to be no reason why several sprays could not be compared in an experiment in which the two sides of a cow were the two experimental units of each "block." If n sprays were to be investigated, $n(n-1)/2$ cows would be required for each replication. The experiment could be designed so that each spray would be compared with every other spray on every cow in the experiment unless the number of sprays applied were too large for that to be feasible. For example, if one had sprays, S_1, S_2, S_3, and check C, six cows would be required for each replication. Six replications would be necessary before all comparisons would have been made on every cow.

The fly counts obtained from that *half-cow* experiment could be analyzed after an appropriate transformation of the data to make their distribution approximately normal. Percentages and individually devised formulas for repellency would not be needed.

While the design just described does make it possible to perform valid statistical analyses of the data so obtained, three objections remain: (1) The mechanics of conducting a *half-cow* experi-

ment on even as few as six sprays and a check would be so complicated that there would be considerable chance for errors to creep in. (2) There is nothing in such an investigation as usually conducted—beyond the accumulation of an excessive amount of data—to guard against interactions with weather. If S_1 and S_2 were compared on a hot, bright day and on a light-colored cow; and S_1 and S_3 were compared on the same cow on a dark, cool day; there clearly would be a distortion of the true comparisons among those sprays. (3) No refinement of the statistical analyses can remove whatever difficulties arise from the odors of different sprays on the same cow, and from the movements of a cow's head and tail.

The second objection can be removed by combining with this design the technique of a preliminary balancing of groups of cows. If three replications of the six comparisons among S_1, S_2, S_3 and C are to be run, the necessary eighteen cows would be divided into a group of six cows adjudged to be of relatively high susceptibility to flies, another of medium attractiveness to flies, and a third of low susceptibility. The six cows in each susceptibility-class would be assigned by chance to one of the six comparisons to be studied.

It seems proper to conclude from the information now available that the *half-cow* technique can be made an objective method for conducting cattle spray tests under field conditions, and may prove to be a reliable method. Such a procedure would be more complex to carry out than is the *whole-cow* method, but whether the complexity would be compensated for by the precision gained is yet to be determined. Information on this point is now being accumulated at the Kansas Agricultural Experiment Station by using the *half-* and the *whole-cow* methods concurrently and by studying the effect of spray on one side of a cow on the fly numbers for the unsprayed side.

NECESSITY FOR TRANSFORMATION OF DATA FROM NON-NORMAL POPULATIONS.—Many experiments employing biological materials produce data which safely may be considered as sampling data from a normal population. In other instances—especially those involving enumeration—it would partially impair all conclusions drawn to assume that the distributions were normal.

One phase of cattle fly spray research is concerned with the numbers of flies found on the cows at regular periods throughout the day. A large share of the counts lies in a fairly narrow range limited at one end by zero but practically unlimited at the other end. The result is a Poisson-like distribution of the counts. Under such circumstances, normal sampling theory would be of doubtful validity, and the arithmetic mean would not typify a group of such counts well. Furthermore, it would be quite misleading to present arithmetic means and standard deviations in the usual form: $\bar{x} \pm s$. These points are illustrated by the data displayed in table 1, where information is presented from counts on unsprayed cows and also on cows which had been sprayed with six different sprays.

Table 1.—Arithmetic means, modes, standard deviations, ranges, and the intervals, $x \pm ks$, for one series of fly spray tests. (504 counts made with each spray and check.)

Spray	Mode	($\bar{x}$) Mean	(s) Stand. Dev.	Range	$\bar{x} \pm s$	$\bar{x} \pm 6s$
Check	17	34.80	35.60	0–362	⁻0–70	⁻0–248
#1	0	20.31	20.72	0–152	⁻0–41	⁻0–145
#2	0	19.26	21.48	0–176	⁻0–41	⁻0–148
#3	8	16.82	15.90	0–113	1–33	⁻0–112
#4	0 & 11	16.47	14.24	0–138	2–31	⁻0–102
#5	0	15.10	14.22	0– 89	1–29	⁻0–100
#6	0	14.10	14.87	0–115	⁻0–29	⁻0–103

The symbol, ⁻0, means that the indicated range extends below zero, where no counts exist.

The following features are found in table 1 both for check and for non-check counts: (1) The modal count is always considerably less than the mean count. (2) The mean is far to the left of the center of the range in all instances. (3) The interval, $\bar{x} \pm s$, includes most of the counts less than the mean, but falls far short of the upper boundary of the observed range. (4) The interval, $\bar{x} \pm 6s$, fails to include all observations larger than the mean in all but one sample. (5) The size of the sampling standard deviation, s, follows the size-trend of the sampling mean, $\bar{x}$. These general features were observed in every series of tests conducted at the Kansas Agricultural Experiment Station. They demonstrate an extreme lack of normality in the populations sampled.

The fifth point above merits further consideration. It is clear that an observed difference in average fly repellency which would be considered important between

two highly repellent sprays would not necessarily be significant when two less repellent sprays were being considered: the larger averages are subject to more variability than the smaller averages. It would facilitate the interpretation of such data if that situation did not exist. Moreover, conclusions drawn without taking recognition of those unequal variances within groups would risk serious error.

Geary (1936) has shown that the normal distribution is the only one for which the sample mean and the estimated variance (s^2) are independent. Hence, large averages are not subject to more variability than the smaller averages if a normal population is being sampled.

The product-moment coefficient or correlation (r) between the means of table 1 and the corresponding variances (s^2) is 0.990. This coefficient exceeds the value 0.951, which, for 5 degrees of freedom, would be the product of sampling variation alone about one time in 1000 samples. Hence it would be unsound to set up the Null Hypothesis that all seven samples had been drawn from the same normal population.

Some of the statistical techniques, whose use is most desirable in the analysis of data obtained from cattle fly spray tests, assume normality of distribution and require essentially equal variances for the samples studied. It is, therefore, desirable to normalize the available data so as to remove reasonable doubt of the validity of the processes employed. Two questions are immediately posed: (1) How much non-normality of distribution can the desirable statistical techniques tolerate? (2) How can one normalize such data? The answers to both questions are fraught with some vagueness and some lack of mathematical precision, but are reasonably satisfactory for practical purposes.

Bartlett (1936), Bliss (1937), and Cochran (1938) have not only developed methods for normalizing data, but also have shown that the analysis of variance and the t-test can tolerate considerable non-normality of distribution without leading to biased conclusions. It appears now that if the correlation—either linear or curvilinear—between $\bar{x}$ and s^2 has been removed, whatever non-normality of distribution remains usually is of minor importance.

The general method developed by those investigators for deriving transformations designed to normalize data demands a knowledge of the approximate relationship between the sampling mean, $\bar{x}$, and the sampling estimate of variance, s^2, or V. That relationship is often indicated adequately by a scatter diagram. A transformation,

$$y^2F(x),$$

is then sought which will remove the correlation between $\bar{x}$ and V. This is accomplished upon the basis of certain assumptions and approximations described in other publications (*l. c. supra*). The practical justification of the method used must, and does, lie in the end result: The production of distributions which are satisfactorily normal and whose sampling features have not been seriously distorted. The normalization will be considered accomplished if the linear correlation between $\bar{x}$ and V has become definitely non-significant, and the scatter diagram does not indicate a remaining curvilinear relation between $\bar{x}$ and V. Whenever it is possible to obtain an adequate sampling distribution, it should appear to be approximately normal. However, one is rarely able to judge well of the latter feature. As long as the group means are subject to about the same variability, a definite improvement in the statistical analysis has been accomplished by the transformation.

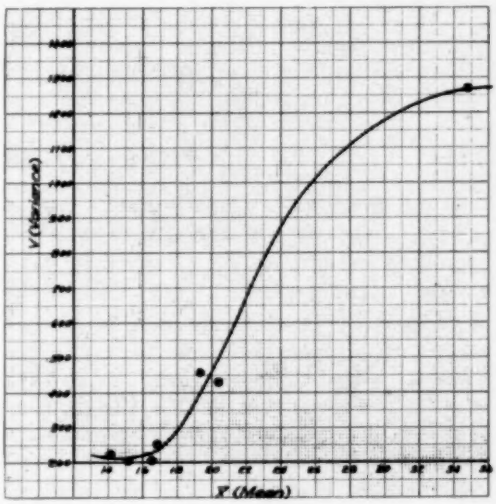

FIG. 2.—Scatter diagram for spray of series 4.

In order to illustrate the previous dis-

cussion, the data of table 1 are used again. Those data lead to the scatter diagram of figure 2, the curve being ignored for the present.

The linear correlation coefficient of 0.990, already given for the data partially described by figure 2, would ordinarily be taken to indicate a rather good linear relation between $\bar{x}$ and V. If it is assumed that

$$V = a\bar{x} + b,$$

a square root transformation,

$$y = \sqrt{x + c},$$

where c is constant, is suggested by the usual procedure for obtaining such transformations. It has been found advantageous to use $c = 0.5$ when many of the counts are below 10 (Bartlett 1936).

Table 1 indicates that the modal count was usually zero; so the transformation,

$$x = \sqrt{x + 0.5},$$

was used. Even though the transformed data were much more nearly normally distributed than the untransformed data, the $\bar{x}$ and the V were still definitely correlated for the data of table 1. The correlation coefficient was 0.964 after the square root transformation had been employed. Hence, it was still true that the small $\bar{x}$'s were subject to significantly less variability than were the large $\bar{x}$'s.

A closer examination of figure 2 suggests the cause of the partial failure of the square root transformation. The six "spray" points tend to follow a parabolic trend which, however, does not include the "check" point on the diagram. As far as the "spray" points are concerned, the relation between $\bar{x}$ and V is probably this:

$$V = a\bar{x}^2 + b\bar{x} + c.$$

Such a relation would call for a logarithmic transformation of the type,

$$y = \log\ (x + c).$$

The check counts could be omitted from the analyses to follow, but almost everyone interested in such research prefers to keep the check results in the analyses in order that certain comparisons may be made, and the lasting qualities of the sprays may be studied. Hence, it was deemed important to try to find a transformation that would allow that to be done. It was found that, after the use of the transformation finally adopted, the variance of the check counts was not sensibly different than for the sprays and was even less than that for some of the sprays. Hence, it apparently did not reduce the precision of the comparisons among the sprays to keep the check data in the analysis.

In figure 2, the relation between $\bar{x}$ and V is probably cubic, as indicated by the line drawn into the scatter diagram. If it is assumed that

$$V = a\bar{x}^3 + b\bar{x}^2 + c\bar{x} + d,$$

the reciprocal square root transformation,

$$y = \frac{1}{\sqrt{x + c}},$$

is derived after certain approximations have been employed. Hence the data in Series 4 (summarized in table 1) were transformed in that manner. The c was taken as 10, but the best value for c is still being investigated. However, it was determined that neither the square root nor logarithmic transformations is successful with $c = 10$. After transformation by

$$y = \frac{1}{\sqrt{x + 10}},$$

the linear correlation between $\bar{x}$ and V

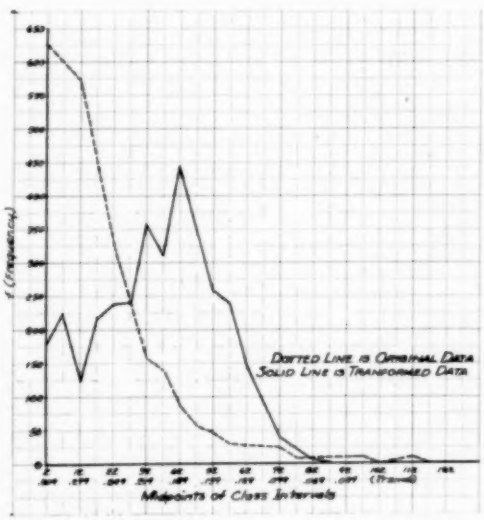

FIG. 3.—Frequency distribution of counts before and after transformation by the reciprocal square root transformation.

was 0.460, which, for 5 degrees of freedom, is well within the bounds of experimental variation. Thus the reciprocal square root transformation has fulfilled the most important requirement for a satisfactory normalization of the fly count data.

A typical example of the untransformed and the transformed frequency distributions of the fly counts obtained in Series 4 is presented in figure 3. Two points may be made from that figure: (1) A great improvement in the distribution has been accomplished through the use of the reciprocal square root transformation. (2) The natural boundary of counts on the left is still producing some skewness in the distribution of the transformed counts. Much of that latter effect can be removed, it is thought, by eliminating the early morning counts when most of the zeros are obtained.

Even in the present situation, the remaining skewness was not considered as very important since the correlation between $\bar{x}$ and V was no longer important. Furthermore, the scatter diagram for the transformed data showed no sign of a curvilinear relation between $\bar{x}$ and V.

Upholt (17) has reported a hypothetical experiment in which the square root transformation apparently introduced considerable variation among the means of the groups used. He then observed that tests of significance applied to the transformed data would need to be of low enough power to fail to pick out the artificial differences introduced by the transformation and yet of high enough power to be useful. He concluded that the analysis of variance and the t-test probably did not detect the artificial differences but also lack power as tests of significance.

The data, upon which the present paper is based, do not support Upholt's finding that transformations introduce variability among the group averages. It can be observed from table 2 that the coefficient of variation is always less for the transformed than for the untransformed data. Upholt started with groups whose means were almost identical so that any change in their variation must be for the worse. There is a question whether the square root transformation introduced more than random variation into Upholt's data; and, whether it reduced the variation signifi-

Table 2.—Means and coefficients of variation by sprays groups before transformation of counts and after.

Transformation	1	2	3	4	5	6	7	Coefficients of Variation	
								All sprays	Without check
None	34.80	20.31	19.26	16.82	16.47	15.10	14.10	0.362	0.141
$\sqrt{X+0.5}$	5.56	4.09	3.94	3.79	3.69	3.54	3.38	0.182	0.0695
$1/\sqrt{X+10}$	0.169	0.206	0.209	0.212	0.215	0.220	0.225	0.0885	0.0330
None	66.98	22.27	20.65	19.57	18.25	15.12	14.50	0.734	0.102
$\sqrt{X+0.5}$	7.42	4.29	4.10	4.07	3.89	3.57	3.48	0.309	0.0815
$1/\sqrt{X+10}$	0.139	0.200	0.201	0.204	0.210	0.218	0.222	0.140	0.0439
None	45.0	45.4	36.0	34.3				0.146	0.155
$\sqrt{X+0.5}$	6.71	6.73	5.92	5.79				0.0798	0.0828
None	39.6	40.6	20.2					0.343	too
$\sqrt{X+0.5}$	5.57	5.44	3.92					0.184	few
None	35.1	20.0	16.7	13.0				0.458	0.211
$\sqrt{X+0.5}$	4.86	3.89	3.50	3.00				0.207	0.129
None	59.1	43.4	22.4	12.0				0.617	0.618
$\sqrt{X+0.5}$	7.04	5.82	4.08	2.96				0.363	0.476
None	42.4	15.6	12.6	11.0				0.725	0.179
$\sqrt{X+0.5}$	6.51	4.03	3.52	3.31				0.341	0.102

cantly in our study. No test of significance for the coefficient of variation is known (Snedecor 1940).

While it is admitted that the transformation of data deserves much more study, the authors of this paper feel that its use has increased the reliability and the precision of the analyses of the data obtained during the two summers of fly spray research. More evidence on this point will appear later in this paper.

EVIDENCE FROM ACTUAL DATA THAT TRANSFORMATION OF FLY COUNTS INCREASES PRECISION OF STATISTICAL ANALYSES.—The reciprocal square root transformation reduced the linear correlation between $\bar{x}$ and V to definite nonsignificance, made a very marked improvement in the observed distribution of the fly counts, and left a scatter diagram which gave no evidence of a remaining curvilinear relation between $\bar{x}$ and V. In addition to those evidences of the success of that transformation, it seems worthwhile to show that different conclusions are drawn from analyses of data which are untransformed, unsuccessfully transformed, and successfully transformed. This will be done with

$$y=\sqrt{x+0.5}$$

as the unsuccessful transformation, and

$$y=\frac{1}{\sqrt{x+10}}$$

as the successful transformation.

Table 3.—Comparison of analyses after the two transformations: $y_1=\sqrt{x+0.5}$ and $y_2=1/\sqrt{x+10}$. (x = actual fly count.)

SOURCES OF VARIATION	DEGREES OF FREEDOM	ESTIMATES OF σ^2 (Mean Square) y_1 data	F[1]	y_2 data	F[1]
Groups of cows	3	3.1602[2]	1.56	0.001045[2]	1.40
Cows within groups	12	73.022[3]	36.18	0.02604[3]	34.79
Hour of day	8	17.477[3]	8.66	0.01024[3]	13.68
Days	3	14.920[3]	7.39	0.007064[3]	9.44
Hour×group interaction	24	1.7762[2]	0.88	0.0006637[2]	0.89
Day×group interaction	9	2.0096[2]	1.00	0.0006744[2]	0.90
Remainder	516	2.0182		0.0007485	
Total	575				

[1] For simplicity of presentation, the Remainder Mean Square was used to calculate F in all instances.
[2] Probably experimental variation only.
[3] Would not occur from experimental variation on an average of one time in 1000 samples from same normal population.

The results from the other series of tests in which six sprays were tested were essentially like those for Series 4. But, in 1940 and the first half of the tests in 1941, when but three sprays and check were compared, the square root transformation,

$$y=\sqrt{x+0.5}$$

was found to normalize the data adequately. It was hoped that the reciprocal square root transformation might be general enough to normalize the same distributions that the square root transformation would normalize plus some that the latter would not normalize. It was found that the reciprocal square root transformation did equalize the variances in the three-spray tests at 1940 and 1941 and remove their dependence upon the sample means.

It is important to know that, when two transformations can be found which both normalize a given distribution, the conclusions which are drawn from the two subsequent analyses are in agreement in all essential respects. This was found to be true and is illustrated in table 3 for some of the data taken in 1941.

The data obtained in Series 3 and Series 4 were analyzed from two different classifications: (1) The usual Period×Group arrangement for the 7×7 Latin squares previously described; and, (2) a Spray×Hour classification in which the balanced groups of cows were the units. The first form was used to obtain the best comparison of the over-all effects of the different sprays during the whole period of the tests, and to study the group-to-group and the period-to-period variation observed. The second organization of the data made

it possible to study the lasting qualities of the sprays throughout the day, and to learn if there were a spray×hour interaction. If there is no such interaction, the sprays compare about the same throughout the day, and certain improvements in technique can be introduced.

The analyses of the data were accomplished through analysis of variance and the t-test following methods fully described by Snedecor (1940), Goulden (1939), Paterson (1939), and others. The results of the analyses after no transformation, an unsuccessful one, and a successful one are presented in tables 4 to 8.

Table 4.—Ordered "over-all" spray means of untransformed data, and least significant differences. (Each mean is based on 504 hourly counts on individual cows.)

Series 3		Series 4	
Spray	Mean	Spray	Mean
5% *Thanite*	14.50	#6	14.10
5% *Thanite*	15.12	#5	15.10
5% Pyrethrum	18.25	#4	16.47
2½% Pyr. & P.O.	19.57	#3	16.82
2½% Pyr. & *D.H.S.*	20.65	#2	19.26
2½% Pyrethrum	22.27	#1	20.31
Check	66.98	Check	34.80

Least significant differences:
6.09*; 8.20**; 10.87*** 5.45*; 7.33**; 9.72***

Conclusions: The top spray is significantly more repellent than the bottom two in Series 3, and than the bottom one in Series 4. In both series the differences do not reach the 1 per cent level (**). In both series, all sprays are significantly repellent (as compared to check) at the 0.1 per cent level (***).

The phrase, "least significant differences," refers to those differences between means which, with specified degrees of confidence, can be considered as not due to sampling variation. A difference which would not be produced one time in twenty on the average, by sampling variation alone is called "significant" and is indicated by one asterisk (*). Such a difference which should have an average occurrence of less than one time in one hundred samples if chance is the only source of variation, is indicated by two asterisks (**); and for chances of one in one thousand, the symbol is three asterisks (***). A "significant" difference between the average repellencies of two sprays suggests that those two sprays differ fundamentally in their qualities as fly repellents. It is obvious that the 1 per cent (**), and the 0.1 per cent (***) levels of significance furnish increasingly stronger evidence of basic differences between the sprays compared.

Table 5.—Ordered "over-all" spray means after square root transformation and least significant differences. (Each mean is based on 504 hourly counts on individual cows.)

Series 3		Series 4	
Spray	Mean	Spray	Mean
5% *Thanite*	3.48	#6	3.38
3% *Thanite*	3.57	#5	3.54
5% Pyrethrum	3.89	#4	3.69
2½% Pyr. & P.O.	4.07	#3	3.79
2½% Pyr. & *D.H.S.*	4.10	#2	3.94
2½% Pyrethrum	4.29	#1	4.09
Check	7.42	Check	5.56

Least significant differences:
0.37*; 0.50**; 0.67*** 0.37*; 0.50**; 0.87***

Conclusions: The top spray in Series 3 is now significantly more repellent than four other sprays at the 5 per cent level than three other sprays at the 1 per cent level; and, than one other spray at the 0.1 per cent level of significance. Somewhat similar statements hold for Series 4; hence precision apparently has been added to the comparisons even when a partially unsuccessful transformation has been applied. It is noted that all sprays hold the same rank as in table 4.

Tables 4, 5, and 6 present analyses of the over-all repellencies of the sprays tested. The appropriate conclusions are drawn below each table.

Tables 7 and 8 present hourly means before and after a transformation of the data, and hence offer an opportunity to study both the effects of the transformation and the manner in which the effectiveness of the sprays persisted throughout the day. Numerous particular comparisons could be made from those tables, but it suffices to say that there is again evi-

Table 6.—Ordered "over-all" spray means after reciprocal square root transformation differences. (Each mean is based on 504 hourly counts on individual cows.)

Series 3		Series 4	
Spray	Mean	Spray	Mean
5% *Thanite*	0.222	#6	0.225
3% *Thanite*	0.218	#5	0.220
5% Pyrethrum	0.210	#4	0.215
2½% Pyr. & P.O.	0.204	#3	0.212
2½% Pyr. & *D.H.S.*	0.201	#2	0.209
2½% Pyrethrum	0.200	#1	0.206
Check	0.139	Check	0.169

Least significant differences:
0.009*; 0.012**; 0.015*** 0.009*; 0.012**; 0.016***

Conclusions: The top spray in Series 3 is significantly more repellent than four other sprays at the 1 per cent level; and than three others at the 0.1 per cent level of significance. Likewise, in Series 4, there is an increase in the precision of the comparisons as made in table 5 after the square root transformation. Compared to the analysis of the untransformed data, a great deal of precision has been added by using the reciprocal square root transformation. The sprays still hold the same rank as in tables 4 and 5.

dence of an increase in precision associated with the increase in normality of distribution produced by the reciprocal square root transformation. Thus a better study of the lasting qualities of the sprays probably has been obtained by using that transformation prior to statistical analysis.

Table 7.—Hourly spray means for the untransformed data of Series 4. Each mean is based on 63 counts.

Spray	Hour 7	8	9	10	11	12	1	2
#6	2.56	4.73	7.60	13.32	18.59	17.14	20.89	27.67
#5	2.92	6.84	10.57	16.71	19.00	18.41	21.21	24.32
#4	3.56	7.06	11.68	18.46	21.35	20.37	21.03	25.38
#3	5.43	9.43	15.17	17.35	19.95	21.51	23.54	24.00
#2	3.56	8.54	15.29	22.51	27.08	25.00	25.94	26.05
#1	5.30	13.65	20.16	25.06	24.63	22.33	26.25	25.24
Check	32.43	36.11	37.52	47.90	38.14	32.40	32.40	33.73

Least significant differences within spray or hour: 10.89*; 14.32**; 18.15***.

Table 8.—Hourly spray means for the data of Series 4 transformed by the reciprocal square root transformation.

Spray	Hour 7	8	9	10	11	12	1	2
#6	.287	.267	.247	.218	.203	.204	.194	.178
#5	.287	.255	.234	.209	.197	.197	.194	.186
#4	.279	.249	.227	.201	.193	.194	.194	.181
#3	.265	.243	.216	.203	.196	.194	.188	.188
#2	.280	.246	.214	.196	.186	.190	.183	.177
#1	.271	.235	.205	.193	.189	.191	.182	.180
Check	.187	.169	.168	.160	.167	.172	.166	.163

Least significant differences within spray or hour: 0.024*; 0.032**; 0.041***.

The analysis of the data summarized in table 8 brought out a point regarding technique. There is no evidence of a spray ×hour interaction. As table 8 indicates, the sprays compared the same from hour to hour throughout the day. Hence, it seems that one could dispense with so many hourly counts and still obtain reliable data. It is possible, by means of the "least significant differences" below table 8, to be more specific. No two of the 7:00 o'clock means are significantly different; so the counts need not start before 8:00 o'clock. By that time, one highly significant difference has developed. It also appears from table 8 that there are no changes of importance among the counts between 10:00 o'clock and 1:00 o'clock for any particular spray. The effects of the sprays are not all gone, or nearly so, by 2:00 o'clock; hence, later counts are suggested. One could very probably obtain more information from six counts at 8:00 or 8:30, one and two hours later, and then at 1:00 or 1:30, and one and two hours later, than was obtained by the eight hourly counts previously listed.

The elimination of the early morning count would tend to improve the distribution of the data. Part of the effect of the left-hand boundary would be removed, and one could expect that some of the skewness remaining in the transformed distributions would be removed. In Series 4, 120 of the 182 zero counts were obtained at 7:00 o'clock. Moreover, when counts are at a natural boundary, they furnish very little information concerning the relative efficiencies of the sprays being compared. Hence, it appears that to eliminate the early morning counts would be to improve the data obtained, facilitate and improve the statistical analyses, and save labor with no loss of essential information.

It can be concluded from the previous discussion that the use of the transformation,

$$y = \frac{1}{\sqrt{x+10}},$$

where x is an observed number of flies, has increased the precision of the tests of significance employed. In so doing, the statistical analyses have been made sensitive enough to non-random variations produced by the different insecticides employed that certain sprays can be characterized as very probably superior to others whereas analyses on the untransformed data fail to detect those differences. Since the coefficients of variation were observed to decrease after the transformation used, and since Upholt gives evidence to show that the F and t-tests may lack power to detect some differences which do in fact exist, it seems safe to conclude that those differences in repellency which are detected in table 6 very probably do exist. These results are out of accord with Upholt's conclusion that a transformation of data followed by the analysis of variance and the t-test is of doubtful value to the experimenter.

BALANCING GROUPS OF COWS IN RESPECT TO FLY SUSCEPTIBILITY.—The process of balancing groups of cattle with regard to attractiveness to flies can include two phases profitably: (1) one during which dairymen attempt to make up balanced groups on the basis of color, size, age, breed, stage of lactation, and any

other factors which are believed to affect susceptibility to flies; and, (2) another during which a uniformity trial is run on the groups selected to test their balance. This phase includes any regrouping found to be necessary.

Little need be said here regarding the first phase beyond the obvious fact that the wider the range of susceptibilities studied, the broader the application of the results obtained, if there is no interaction with level of susceptibility. Even then, a better study may be possible with the wider range. The balance of the group should include a balancing of the cow-within-group variability, in addition to an equalization of their total attractiveness to fly populations. These requirements can be met satisfactorily after counts from preliminary trials are available.

With the range of susceptibilities existing in the Kansas Agricultural Experiment Station herd, three-cow and four-cow groups were balanceable. However, there was evidence that the cow-within-group variance was approaching non-homogeneity for the seven groups of three cows each. That same feature, but less pronounced, was found among the four-cow groups. It is believed that more care in selecting the groups will completely remove this difficulty. If not, more cows per group would be required.

The first two series of trials run during 1941 utilized four-cow groups. A uniformity trial with no spray was run for four days. During that time, nine hourly counts were made on each of the sixteen cows in the test. These data were analyzed as shown previously in table 3, after the use of two different transformations. Those two analyses agree in making possible the following conclusions:

(1) The "group" means square is not importantly greater than the "remainder," or either of the two interaction mean squares. Hence, the groups appear to have been well balanced as regards numbers of flies attracted.

(2) There is a considerable amount of variability among the cows within a group as shown by that mean square's significance even beyond the 0.1% level. This fact, plus the one noted in (1), indicates that, even though the range of susceptibilities was quite wide, the dairymen were successful in efforts to balance the groups of cattle with regard to fly susceptibility.

(3) The days during which the uniformity trial was run were different enough that the cows were tested under conditions that produced changes in susceptibility. This follows from the measure of day-to-day variation given by the "days" mean square.

It may be concluded that a herd of cows exhibiting a fairly wide range of attractiveness to flies has been segregated into groups which, within the bounds of chance variations, were equally attractive to flies over a period of time during which the factors influencing susceptibility to flies were varying quite markedly. When such groups are employed in a properly designed experiment, it is possible, through the analysis of variance and t-test, to draw valid and useful conclusions regarding the relative efficiencies of different fly-repelling sprays. This has been done in a separate paper (Shaw *et al.* 1943[1]).

SUMMARY AND CONCLUSIONS.—(1) Testing cattle sprays on the cattle themselves is complicated by the number of variables present in such research. That situation logically requires objective and standardized techniques in planning the experiment, in carrying it through, and in the final interpretation of the data obtained.

(2) A review of the literature on cattle fly spray tests indicates that, although considerable progress has been made in developing general techniques and in discovering the variables involved, very little data and few statistical analyses have been presented in support of the conclusions drawn.

(3) Periodic counts of the flies present on cows are distributed in a Poisson-like manner that is now even approximately normal. This circumstance forbids the use of statistical techniques based on normal distributions unless the data can be normalized to a satisfactory degree before the analysis is undertaken.

(4) Statistical research has led to a general method for determining a transformation which usually will normalize a set of such data satisfactorily. The application of that procedure to the data obtained from a comparison of six repellent sprays and a check produced a new transformation, the reciprocal square root transformation,

$$y = \frac{1}{\sqrt{x+10}}.$$

This transformation was successful under the peculiar circumstances met in fly spray research whereas other previously

[1] See Literature Cited.

used transformations failed to normalize the distributions of counts satisfactorily.

(5) From research at this station, it appears that a randomized latin square design on balanced groups of cows and different periods of time during the summer is well-adapted to cattle fly spray research.

(6) A general design for a *half-cow* method of testing sprays is suggested. Such a design would standardize the test and make a statistical analysis of the data so obtained possible; but, if practical difficulties make it impossible to compare properly two different sprays on the same cow, the newer design would not make the *half-cow* technique satisfactory.

(7) Evidence from analyses of actual data indicates that the application of a well-chosen transformation will increase considerably the precision of the spray comparisons and the study of the lasting effects of sprays throughout the day.

(8) Analyses of variances have shown that groups of three or four cows can be balanced with regard to fly susceptibility in the presence of a fairly wide range of individual cow susceptibilities and over a period of several weeks. There was no day $\times$group interaction. Analyses indicated that the cow-within-group variability is approaching non-homogeneity for three-cow groups. This can be remedied by a more careful selection of the groups to that end or by using more cows per group.

(9) For the whole herd involved in the experiments at this station, there was considerable day-to-day variation over a four-day period; but, in the absence of a day$\times$group interaction, it is quite likely that a smaller number of days could be used if necessary.

(10) Analysis of the hourly means and of the numbers of zero counts obtained indicated strongly that to make six counts starting later in the morning, ending later in the afternoon, and omitting certain mid-day counts, would produce better data with less effort than did the eight or nine hourly counts used in the 1940 and 1941 research.

It is recognized by the authors of this paper that the process of transforming data in order to normalize their distribution might benefit by further research designed to make the method more objective and rigorous. However, it is our belief that the statistical procedures and the points of view presented in this paper can be made the basis for a standard and acceptable method for cattle fly spray tests. —12-11-42.

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The Distribution of *Aedes* Mosquito Eggs on Salt Marshes in Florida

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The most important pest mosquitoes in seaboard communities are species of *Aedes*, chiefly *A. sollicitans* (Walk.) and *A. taeniorhynchus* (Wied.), whose principal breeding places are the large salt marshes along the coast. In Florida, *A. taeniorhynchus* is the dominant species. The eggs of these salt-marsh mosquitoes are laid on damp soil. Embryonic development begins at once and is completed in a few days, but the eggs then remain dormant until the marsh is flooded with rain or tide water, whereupon they hatch within a few minutes. In the southeastern states, especially in Florida, several broods of the salt-marsh species may develop during a season, depending upon the frequency of drying and flooding of the marshes.

The salt-marsh areas with which mosquito-control districts are concerned are very large and, as the individual marshes vary greatly in mosquito production, it is highly desirable to study and classify them before beginning control operations. By confining the control work to the important breeding areas, relief can be more quickly achieved and the expense of installation and maintenance of the control system can be kept at a minimum.

Evaluations of the breeding conditions on marshes are customarily made by means of larval surveys. By this method a large number of observations throughout one or more seasons may be necessary before the marsh areas can be correctly evaluated, owing to the limitations of weather and extent of marsh areas to be covered, and to the relatively short periods when broods of larvae are on the marsh.

In an effort to supplement information on potential breeding places we have taken advantage of the egg-laying habits of salt-marsh mosquitoes by collecting samples of marsh soil, bringing them into the laboratory, and flooding them with water to hatch any eggs present. The possibility of using a soil-sampling method as an adjunct to larval surveys in delimiting breeding areas is worthy of consideration, because thus the distribution and density of egg deposits can be studied while the marshes are dry.

The data on soil sampling accumulated during three seasons (1939, 40 and 41) from Florida salt marshes, chiefly those of Volusia County: are summarized in this paper. During this period a total of 12,203 soil samples were taken.

Table 1.—Hatching of *Aedes* eggs obtained from soil samples collected in Florida, 1941.

County	Number of Series	Number of Samples	Samples Producing Larvae	Number of Larvae
Volusia	219	7,401	624	12,370
Indian River	2	30	2	9
St. Lucie	54	892	105	2,897
Broward	4	125	3	8
Dade	14	468	13	49
Total	293	8,916	747	15,333

METHODS.—The soil samples from Volusia County marshes included a number of series taken along transect lines by a restricted random method. These transects were projected from the edge of the highland across the marsh to streams or natural drains. Thus each transect followed an elevation gradient that passed through the various characteristic ecological zones. The samples were taken at 20-foot intervals along the transects. During the first 2 years samples also were taken in sets of five at 100-foot intervals. As only slight differences occurred in data obtained by the two methods, and as these differences were in favor of the samples taken every 20 feet, group sampling at the 100-foot intervals was discontinued. At the time of sampling, data were taken on the soil moisture, water salinity, vegetation, and position of each sample in relation to the general level of marsh surface.

The samples were cut with an imple-

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ment made by mounting a ring of heavy sheet iron, 3.2 inches in diameter and 1 inch wide, on the end of a 3-foot hoe handle. With this tool, which resembled a long-handled biscuit cutter, a segment of soil 8 square inches in area was cut on the marsh surface, and a sharpened mason's trowel was then used to slice off and lift the disk of soil. Samples about 1 inch thick were handled most easily. Each sample was placed on an absorbent paper plate, numbered, and brought to the laboratory for storage and flooding. During periods of mosquito activity it was necessary to hold the samples for about a week before flooding, so that any recently laid eggs would have ample time to develop. To prevent egg deposition on the samples after collection they were stored in a screened room.

Either quart mayonnaise jars, from which the top portion had been cut, or beakers (600 to 1000 cc. capacity) were used as containers for flooding the samples. Rain water was the flooding medium used, although sea, distilled, and shallow well water are nearly as satisfactory. For observations of hatching, the jars were placed on narrow shelves towards the light on a screened porch. This arrangement gave a back lighting which was ideal for finding and counting the larvae. As conditions in the hatching jars are often unfavorable for development, the larvae should be counted within 24 hours.

EXTENT OF SAMPLING.—During 1939 and 1940 preliminary studies were made of collecting and flooding procedures, and some information was obtained on the relation of season and climate to egg density on the marshes. In these studies 80 series, totaling 3287 samples, were collected. Eggs were present on 358, or 10.9 per cent, of these samples, and a total of 13,281 larvae hatched. During 1941, as is shown in table 1, hatching occurred from 8.4 per cent of the samples. The samples were taken at fairly regular intervals throughout the season and were handled in a uniform manner to test such a method for general survey use.

SEASONAL VARIATION IN EGG DENSITY.—Our observations have shown that eggs are not abundant on the open marshes of Volusia County in the spring until after mosquito flights have occurred. This condition is illustrated by records made at regular intervals during 1941 on 19 marshes. Previous to spring flights only 11 or 0.7 per cent, of 1658 samples showed eggs to be present, the average hatch being 0.1 larva for all samples, whereas following mosquito flights 282, or 12.5 per cent of 2255 samples, showed eggs to be present, the average hatch being 1.6 larvae per sample.

Although few eggs have been found on the open marshes previous to the first mosquito flights of the season, the data in table 2 show that during this period eggs were found readily in miscellaneous locations, such as pond rims and areas of poor drainage adjacent to the marshes. The explanation seems to be that the open marshes in Volusia County are largely flooded to a considerable depth by high tides during the latter part of September and October, and the only locations available for oviposition are those that do not remain continuously flooded during the last mosquito flights of the season. A scarcity of larvae on the open marshes during early spring floodings previous to the first mosquito flights has also been noted, which supports the data given herein showing that few eggs remain on these marshes throughout the winter.

Table 2.—Hatching of *Aedes* eggs from soil samples from marshes and other locations previous to mosquito flights. Volusia County, Fla., 1940-41.

Location of Samples and Year	Number of Series	Number of Samples	Per Cent of Samples Producing Larvae	Average Number of Larvae	
				In All Samples	In Samples Producing Larvae
Marsh:					
1940	21	1,798	1.1	+	3.4
1941	38	1,658	0.7	0.1	19.6
Total	59	3,456	0.9	0.1	8.8
Other locations:					
1940	19	275	15.3	7.9	51.6
1941	17	324	23.8	9.6	40.5
Total	36	599	19.8	8.8	44.4

EFFECT OF FLOODING MARSHES ON EGG DENSITY.—In laboratory tests it was found that at least 90 per cent of the mosquito eggs on soil samples would hatch with the first flooding. The same condition apparently occurs in the field, as is shown by the following records obtained during the breeding season: While the marshes were flooded and unfavorable for sampling, only 25 larvae were found from 10 series totaling 226 samples, or an aver-

age of 0.1 larva per sample; from the same marshes, when dry and favorable for sampling, 1503 larvae resulted from 18 series totaling 454 samples, or an average of 3.3 larvae per sample. Flooding had therefore caused the hatching of about 97 per cent of the eggs.

Further indication that most of the eggs hatch on the marshes as they become flooded is shown by the following: On August 20, 1940, 120 samples were taken from the rim of a pond that was known to produce large numbers of mosquitoes; 113 of these samples produced a total of 8205 larvae, or an average of 68.4 for all samples. On September 5, 1940, after several heavy rains which partially flooded the marsh, 36 of 48 samples from this location produced a total of 657 larvae, or an average of 13.7 for all samples. Between the time of a general marsh flooding on September 18, 1940, and the first flight of mosquitoes the following summer, 4 series totaling 73 samples were taken at various intervals, from which only nine larvae, or 0.1 per sample, were obtained, and these were all from one sample.

EFFECT OF DITCHING ON EGG DENSITY.—The records of egg density on ditched and unditched portions of three marsh areas, as obtained in four collections in 1941, are summarized in table 3. Area 1 was a marsh that was uniform in contour and vegetation, with a cover of *Juncus roemerianus* Scheele, *Distichlis spicata* (L.) Greene, *Salicornia perennis* Mill., *Batis maritima* L., and *Avicennia nitida* Jacq.; 4 sections of this marsh were ditched and 1 was left unditched. On this area there seemed to be little or no difference in the number of eggs found on the ditched and unditched sections. Area 2 was also a marsh that was uniform in contour and vegetation, which consisted of *Distichlis*, *Salicornia*, and *Spartina bakeri* Merr.; one portion was ditched and one unditched. Area 3 consisted of three small islands on each of which the vegetation consisted of *Salicornia*, *Batis*, *Avicennia*, and *Distichlis;* two of these islands were ditched and one was unditched. In areas 2 and 3 many more eggs were present on the unditched than on the ditched sections. The differences may have been due to differences in ecological conditions. It appears, however, that under certain conditions the ditching of a marsh may make it less favorable for oviposition.

Studies made on a marsh having rather uniform ecological conditions show that as many eggs are laid near the ditches as away from them. From a strip of this marsh 200 feet wide crossing the ditches at right angles in the heaviest breeding portion, 2 series of samples, one in July and one in August, were taken from sections having ditch spacings of 50, 75, and 150 feet. The sample lines in these sections were 5, 15, 25, and 35 feet from the ditches and parallel to them. Random samples were taken 20 feet apart along each line, or a total of 10 samples per line. The data summarized in table 4 indicate some differences in egg density at the various distances from the ditch, but when the data were treated statistically no significant difference was found. Likewise the egg densities at the 5-, 15-, and 25-foot spacings, in which more records could be compared, showed no significant differences. A rather uniform egg distribution was also found on an unditched portion of the same marsh where six parallel lines at 25-foot intervals were sampled. The mean number of eggs for the 10 samples in each line for a sampling in July was 80.0 ± 11.3, and and for a sampling in August, 36.7 ± 9.8.

Table 3.—Egg densities obtained from four collections during the 1941 season on ditched and unditched sections of three marsh areas. Volusia County, Fla.

AREA	EGGS FOUND PER 100 SQUARE FEET	
	Ditched Sections	Unditched Sections
1	77,670	72,720
2	10,800	444,240
3	17,640	87,840

Table 4.—Egg densities in soil samples collected at various distances from mosquito-control ditches in Volusia County, Fla., July and August 1941.

MONTH	EGGS PER SAMPLE AT VARIOUS DISTANCES FROM DITCH			
	5 feet	15 feet	25 feet	35 feet
July	139	63	108	178
August	71	242	228	81
Average	105	152	168	130

EFFECT OF DIKING ON EGG DENSITY.—Soil samples taken from two ditched

marshes, portions of which had been diked and fitted with tide gates to prevent tidal flooding, showed, in one marsh 66,600 eggs per 100 square feet in the diked portion and 417,600 eggs in the undiked portion and, in the other marsh, 720 eggs in the diked and 243,360 eggs in the undiked portion. Until storm tides flooded over the dikes at the last of the season, the soil in the diked portions was quite dry. These data indicate strongly that the diked areas were less attractive for oviposition.

EVALUATION OF MARSHES AS BREEDING AREAS.—During the 1941 season 23 marshes in Volusia County, some of which are ditched, were sampled for eggs at regular intervals. These records show that the relative importance of the marshes as mosquito producers was determined rather accurately from a single lot of samples taken from each marsh when dry and subsequent to flights of mosquitoes (July, August, and September). Samples taken before mosquito flights had occurred (April and May) did not correctly evaluate the marshes. Previous to spring flights only 0.7 per cent of the samples showed eggs to be present, the average hatch being 0.1 larva for all samples, whereas following flights 12.5 per cent of the samples showed eggs to be present, with an average hatch of 1.6 larvae. The small percentage of samples on which eggs were found, however, showed that, even when taken at the proper season, large numbers of samples are necessary before one may safely draw conclusions.

The data given in table 5 summarize the sampling records on marshes, which have been divided into two groups, heavy and light breeding, based on the total larval production for the season as determined by larval surveys. On five of the marshes the mosquito potential as estimated by larval production was greater than the indicated egg density. However, in only one case was a marsh incorrectly classified as to importance by the soil-sampling method.

The mosquito potential was found to be higher by the soil-sampling method than by the larval survey. This might be expected because the hatching from the soil samples indicates the mosquito production from a complete flooding of the marsh, which seldom occurs. According to some of our records, ditching seems to decrease the attractiveness of a marsh for oviposition, but an important number of eggs continue to be deposited on marshes after they are ditched. The mean egg density for the 16 ditched marshes was 75,510 for each 100 square feet, as compared with a mean of 103,151 eggs for the 7 unditched marshes. The high egg density on the heavy-breeding ditched marshes is due no doubt to the fact that the heaviest breeding marshes in the area under observation have been ditched. Even though rapid drainage normally causes low larval production, the ditched marshes continue to be potential breeding areas, and when control systems fail to function properly because of neglect or unusual climatic conditions, broods of mosquitoes may be expected from them.

Table 5.—Average densities of eggs and larvae for the season for heavy and light breeding marshes, Volusia County, Fla., 1941.

Larvae per 100 Square Feet, Larval Survey	Number of Marshes	Eggs per 100 Square Feet—Soil Sampling				
		May	July	August	September	Total
Heavy breeding:						
13,992	Unditched—5	11,252	22,032	74,736	33,264	141,284
7,677	Ditched—7	0	77,400	28,903	39,086	145,389
Light breeding:						
269	Unditched—2	0	3,060	180	4,680	7,920
589	Ditched—9[1]	0	12,520	3,040	5,560	21,165

[1] Forty-five eggs per 100 sq. ft. in April. No eggs present in other marshes observed in April.

EFFECT OF SURFACE CONTOUR ON EGG DENSITY.—According to their predominating contours marshes were divided into two groups, flat and irregular. The irregular marshes were found to have a slightly higher egg density than the flat marshes. From 66 series totaling 2,768 samples taken from irregular marshes hatching

occurred in 8.7 per cent and 1.5 larvae per sample were obtained; from 95 series totaling 3,394 samples taken from flat marshes, hatching occurred in 7.1 per cent and 1.0 larva per sample was obtained.

Samples from irregular marshes were further classified as to whether they were taken from the bottoms of pot holes or the marsh bottom between hummocks, from sides of pot holes or hummocks, or from tops of hummocks or the marsh surface between the pot holes. Egg densities for these groups, as determined from hatching data on 50 series of samples from 13 irregular marshes as compared with additional data on flat marshes, are shown in table 6. Although eggs occurred on the irregular marshes at all contours, they were found most frequently and in largest numbers at the higher elevations. As the differences are statistically significant, it is apparent that samples taken from the higher contours will be most suitable for survey purposes.

Table 6.—Egg densities of soil samples taken at different surface contours of irregular marshes and on flat marshes as determined from hatching data. Volusia County, Fla., 1941.

Sampling Sites	Number of Samples	Samples Producing Larvae	Larvae per Sample Average
Flat areas	662	7.2%	0.8
Tops of hummocks	379	17.2	3.3
Sides of hummocks	414	11.1	1.8
Bottoms of pot holes	620	10.6	2.4
Total	2,075	10.8	1.9

CORRELATION OF VEGETATION WITH EGG DENSITY.—The distribution of mosquito eggs on marshes was found to be correlated to some extent with vegetation. Actually this is believed to be a correlation with marsh elevation, which is reflected in the vegetative cover. Table 7 shows that eggs occurred in greatest numbers on areas where *Sporobolus virginicus*, *Distichlis spicata*, and *Salicornia perennis* comprised the vegetation. Few eggs occurred where *Spartina bakeri* and *Batis maritima* were dominant. The first group of flora cover the higher marsh elevations where flooding is less frequent and conditions are more favorable for the accumulation of eggs.

Table 7.—Average densities of mosquito eggs during the season of 1941 in soil samples from the predominating vegetations. Volusia County, Fla.

Vegetation	Eggs per 100 Square Feet, Average
Sporobolus virginicus (L.) Kunth., seashore dropseed	21,060
Distichlis spicata (L.) Greene, seashore saltgrass	18,382
Salicornia (chiefly *perennis* Mill.), woody glasswort (dead man's finger)	10,557
Juncus roemerianus Scheele, needlegrass rush (black rush)	7,952
Spartina alterniflora Loisel, smooth cordgrass (tide grass)	3,960
Panicum virgatum L., switchgrass	1,800
Spartina bakeri Merr., sand cordgrass (bunch grass)	900
Batis maritima L., maritime saltwort (pickleweed)	252

MISCELLANEOUS SAMPLINGS IN OTHER COUNTIES.—Miscellaneous samplings in 1940 and 1941 in other counties of Florida have included 99 series totaling 1,965 samples from Dade, Broward, St. Lucie, and Indian River Counties. Only the 1941 samples are included in table 1. Data from these collections in general agree with those obtained in Volusia County. That is, during the winter eggs were not found on open marshes, but in higher elevations on and adjacent to the marshes. During the summer eggs were found in these locations and on some open marshes. In contrast to our experience in Volusia County, however, a large number of the series of marsh samples were negative. Since unfamiliarity with conditions in these localities may have led us to make collections at unfavorable times with respect to previous marsh flooding and mosquito flights, we hesitate to give much weight to our negative findings.

DISCUSSION.—Salt-marsh mosquito surveys made by the soil-sampling method give promise of being a useful adjunct to established larval surveys. Although a single survey by this method has demonstrated the presence of *Aedes* eggs in densities which rate the marshes in the same order of importance as do larval surveys, it must be emphasized that the presence of eggs does not necessarily mean that the marsh is an important producing area. For instance, large numbers of eggs have

been found on formerly heavy producing marshes on which control measures were proving efficient. The presence of eggs does mean, of course, that the marsh is a potential breeding area on which larvae may or may not mature, depending on a variety of factors, chiefly the retention of water on the marsh for a week or so after flooding occurs. In view of this, it can readily be appreciated that before control measures are recommended more information about marsh conditions is needed than is provided by soil sampling alone.

An important finding in connection with these studies was that egg surveys by this method can be made on open marshes only in the summer, when the marshes are dry and following mosquito flights. During the winter the method is useful for locating concentrations of eggs in miscellaneous overwintering places. The location of these overwintering egg deposits and their subsequent elimination may become a highly important control procedure, as, in this locality at least, there appears to be a gradual build-up in mosquito population density as the season advances.

The time required for the collection and subsequent laboratory flooding of soil samples is several times that required for gathering the same amount of information by means of a larval survey. Nevertheless, as soil-sampling work can be done, when the marshes are dry and larval surveys impossible, the two methods supplement each other.

The data on egg densities in Volusia County were gathered from marshes on which the actual mosquito production was determined by larval surveys. The same selection of sampling areas, however, should be followed in any locality where no prior knowledge of conditions is available; that is, all the local marsh types should be represented.

Since the conclusions reached here are based on records from Volusia County only, soil-sampling studies should be made in marshes in other sections of the country, where ecological conditions are different, before their general applicability can be determined. Further work of this kind will undoubtedly provide needed information on conditions governing the mosquitoes' selection of oviposition places in the various regions. With this knowledge it may eventually be possible to make marsh surveys by sampling favorable oviposition places and thus greatly decrease the amount of work which is necessary in random sampling.

SUMMARY.—A method is described for determining the density and distribution of eggs of *Aedes taeniorhynchus* and *A. sollicitans* on salt marshes in Florida. By this method random samples of soil were collected along transect lines on representative marshes. These samples were later flooded and the resulting mosquito larvae recorded. From these records egg densities were computed on an area basis. The data presented were obtained by collecting and flooding 12,203 soil samples taken during 1930–41 from salt marshes along the east coast of Florida, chiefly in Volusia County.

Random samplings made on dry marshes following mosquito flights indicated rather accurately the relative value of the marshes as mosquito producers, but the method did not locate or correctly evaluate the breeding marshes when samplings were made during the late fall, winter, or spring. During these periods eggs were located on higher miscellaneous situations.

On one marsh the eggs were as numerous on a ditched section as on an adjacent unditched section, and in this case as many eggs were found near the ditch as away from it. In the ditched and diked areas observed fewer eggs were found on marshes inside the dikes than on comparable undiked areas. The excessive drying appeared to decrease the attractiveness of the marsh for oviposition. On irregular marsh surfaces the eggs were found to be most abundant on the higher contours. The higher egg densities were found where the dominant vegetation was *Sporobolus virginicus* (L.) Kunth., *Distichlis spicata* (L.) Greene, or *Salicornia perennis* Mill.; lower egg densities occurred where *Juncus roemerianus* Scheele, *Spartina alterniflora* Loisel, *S. bakeri* Merr., or *Batis maritima* L. were dominant.—9-12-42.

Time-Saving Methods for Handling Mosquito Light-Trap Collections

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The use of light traps for sampling the mosquito fauna and for determining the abundance of the various species is an accepted procedure in mosquito-control work. The data obtained from light-trap collections are useful, not only in determining the species present in a community so that control measures can be directed toward the most important species, but also in furnishing an index of mosquito density which will evaluate progress in control if studied in conjunction with climatic conditions over a series of years. The objection to the use of light traps for these purposes is that a large amount of routine work is involved in sorting the mosquitoes from other insects taken by the traps and in the subsequent identification. This is the real objection. For instance, during heavy flights of salt-marsh mosquitoes, collections may be so large that this work, together with tabulating and summarizing the records from a single trap, may require all of one man's time.

Because of the large number of mosquito-control projects now being initiated in War areas, there is a pressing need for the sort of information provided by the operation of mosquito light traps. A study of possible methods of decreasing the time and labor involved in obtaining the essential data from these collections has therefore been made, and the results are presented herein.

Procedure for Handling the Collections.—With a little training, reliable non-technical assistants can separate mosquitoes from other insects in the collections and thereby save considerable time for the skilled technician. After the mosquitoes have been segregated they should be tentatively identified without the use of a microscope and arranged in groups according to species and sex. Mutilated individuals, together with others not readily identified, should be placed in a separate group for closer examination under a binocular microscope. In identifying large numbers of mosquitoes under the microscope, the writers have found that time is saved by first arranging them in a narrow row on a strip of paper about 1 inch wide and 3 inches long. These strips are easily handled under the microscope and identification of specimens rapidly made as the strip is slowly moved with the forefingers across the stage. When it is necessary to handle the insects individually, a pair of sharp-pointed forceps should be used. In this operation much time often can be saved if two persons work together, one person identifying and the other recording.

The writers have used a foot-operated tally register to advantage for counting the dominant species in a collection. This device was made by using a 4- by 12-inch board as a base and fastening to it near the far end an ordinary hand-tally register with the lever upright. A second narrow board, which served as a treadle, was hinged to this base at the near end and extended over the lever of the register. A screen-door spring fastened underneath the table and to the free end of the treadle gave sufficient tension to hold the treadle above the lever. In operation, the foot was placed on the treadle and pressed down against the lever to make a tally for each individual of the species being recorded. The register was removed, read, and reset as the identification of each collection was completed.

In humid regions, or when a trap is operated on a rainy night, the collection must be sorted and identified very shortly after removal from the cyanide jar,[1] or mold may develop. Ordinarily, however, collections may be stored for later identification. Large cardboard pill boxes or half-pint paper food containers are satisfactory for this purpose. These should always be carefully labeled with the location of the trap and date of collection. If the insects are to be retained for some time, they can be protected from museum pests by storing the individual containers in large cans in which paradichlorobenzene has been placed.

The writers have used a cup made of

[1] Melted paradichlorobenzene may be used in the collecting jars if desired.

50-mesh copper screen, which is fitted into the killing jar for receiving the insects as they come through the trap. This arrangement keeps the insects in good condition, as they do not come in contact with the moist cyanide. This is a modification of the practice in New Jersey, where a paper cup is similarly used. A quart jar, rather than the conventional one of pint size, should be used on the trap when large collections are being taken.

SAMPLING METHODS.—This study has involved detailed analyses of the records of collections from four traps operated daily in Volusia County, Fla., from May to October 1941. The data have been summarized according to three intervals of trap operation, namely, daily, every second day, and every third day. The mean daily catches for the various groups of mosquitoes, together with their standard errors for the different collection intervals, are shown in table 1.[2] It is significant that the mean daily catches obtained from the trap operations made every second day and every third day approximate closely the mean catch from traps operated every day. The accuracy of the sampling method is reflected in the standard errors, as the range in magnitude of the errors may be associated with the range in the number of observations in a sample.

Table 1.—Daily mean number of mosquitoes caught per trap when traps were operated at various intervals.

TYPE OF MOSQUITO	INTERVAL OF TRAP OPERATION		
	Daily	Every Second Day	Every Third Day
Salt marsh	42.4±3.5	45.1±4.2	45.2± 6.2
Fresh marsh	20.3±2.4	22.8±3.7	23.0± 4.9
Domestic	10.3± .8	10.3±1.1	11.8± 1.6
Anopheles	15.6±1.2	16.2±1.7	16.5± 2.3
All types	90.4±6.2	94.5±8.9	96.4±12.2

Three of the four mosquito traps from which the records were obtained were located adjacent to salt marshes, but few *Anopheles quadrimaculatus* Say were taken in the collections. In one trap, located about 2 miles inland, this species was taken in moderate numbers throughout the season. The average nightly catch for collections made each night was 9.6, for collections made every second night 10.1, and for collections made every third night 9.7. It appears, therefore, that for this important disease-carrying mosquito the indicated population was practically the same when the trap was operated every second or third night as when operated every night.

In interpreting light-trap collection data, it is usually assumed that daily catches of fewer than 25 mosquitoes indicate that the insects are not present in annoying numbers. Therefore, in comparing seasons or locations, the number of "annoyance-free" nights may be used as a criterion of effective control work. When the data were summarized according to daily mosquito-density groups (Table 2), it was found that the percentage of days during the season falling in these groups varied little when computed from trap records made daily, every second day, or every third day.

Table 2.—Density of mosquito population for various intervals of trap operation throughout the season.

INTERVAL OF TRAP OPERATION	PERCENTAGE OF DAYS DURING SEASON ON WHICH INDICATED NUMBER OF MOSQUITOES WERE CAUGHT PER DAY			
	0 to 25	0 to 50	0 to 100	100 or more
	Salt Marsh			
Daily	65.8	76.3	86.3	13.7
Every second day	65.1	75.0	85.2	14.8
Every third day	68.5	77.3	85.7	14.3
	Fresh Marsh			
Daily	82.9	90.9	94.8	5.2
Every second day	80.9	89.5	93.8	6.2
Every third day	82.8	88.7	94.1	5.9
	Domestic			
Daily	87.7	95.1	98.6	1.4
Every second day	86.2	94.2	99.3	.7
Every third day	91.1	93.6	97.0	3.0
	Anopheles			
Daily	81.6	91.0	97.1	2.9
Every second day	81.5	90.5	96.4	3.6
Every third day	81.3	90.6	96.6	3.4
	All Species			
Daily	46.4	56.1	73.9	26.1
Every second day	46.7	54.9	73.0	27.0
Every third day	48.3	58.1	74.4	25.6

The results of studies made on estimating the total mosquito collection from determinations of various fractions of the whole collection before the mosquitoes were sorted out are shown in table 3. Each collection was well mixed with a spatula before being fractioned and then arranged in an even rectangular pile. Division was then made by eye into the desired fractions in the manner used by druggists for

[2] F. M. Wadley gave advice in the preparation of statistical analyses.

dividing medicinal powders. This method was also tried for estimating the number of mosquitoes in collections from which all other insects had been removed (Table 4). Although variations occur, it appears from these observations that an estimation of the total collection from fractions is sufficiently accurate to warrant its use on large collections, particularly when traps are being used on a practical basis and the labor required to count the whole catch would not be justified. When unsorted collections were used (Table 3), the errors for this method ranged from 1 to 64 per cent, with the smaller error range for the sample consisting of half the total collection. When sorted collections were used (Table 4), the errors ranged from 8 to 35 per cent.

Table 3.—Total catch of mosquitoes and deviation from the total as calculated from different fractions of entire unsorted collection.

Number of Mosquitoes	Per Cent Deviation as Estimated from Indicated Fraction		
	1/8	1/4	1/2
Fresh Marsh			
29	−36	−32	−24
38	−16	+37	0
39	−18	− 8	+28
87	+47	+10	−14
122	+ 5	− 8	− 5
147	+ 9	−18	−13
298	+ 5	−22	+ 9
333	+ 3	−10	− 5
607	+ 4	− 9	− 2
768	+30	+ 3	−16
Anopheles			
39	+ 3	+64	−23
66	−64	−34	0
84	+50	−10	− 7
109	+39	−32	+17
111	+ 1	− 6	− 6
111	−21	+19	+ 6
140	−20	+23	+11
215	−18	+26	+ 2
316	+27	+ 5	−15
323	+11	+10	− 1
All species			
106	−47	−25	−11
132	+33	+27	−15
196	− 6	+ 2	+ 9
254	− 6	− 1	− 1
285	−19	+24	+ 4
405	+ 5	−13	− 5
542	+20	−20	+ 2
740	+ 7	−12	− 2
778	+ 9	− 3	− 5
1,205	+30	+ 4	− 4

Table 4.—Total catch of mosquitoes and deviation from the total as calculated from one-fourth of entire sorted collection.

Total Number of Mosquitoes	Per Cent Deviation
Fresh Marsh	
26	+ 8
85	−15
86	−16
214	−10
896	+ 9
Anopheles	
22	+27
76	+21
95	−13
131	+10
172	+35
All species	
125	+10
190	+18
266	−13
419	+14
954	+ 9

In addition to the foregoing methods of estimating total light-trap collections from fractional samples, the writers measured the volume of several collections in milliliters both before and after sorting out the other insects and used a known fraction of the total volume for estimating the total collection. It was found that by this method the measuring error was too large to be considered.

CONCLUSIONS.—From these studies it is concluded that, for practical control purposes, satisfactory estimates of mosquito abundance can be obtained by operating mosquito light traps every second or third day instead of daily. Also, when several hundred mosquitoes are present in a single collection, it is practical to identify the species in only one-fourth or one-half the catch and to calculate the total collection on the basis of this fraction.—11-3-42.

KEEP ON BUYING WAR BONDS

Studies on Ovicides for the Clear Lake Gnat

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The Clear Lake gnat, *Chaoborus astictopus* D. & S., an annoying pest in the environs of Clear Lake, Calif., lays its eggs on the surface of the lake during warm, calm evenings. The eggs usually concentrate into large drifts, which are moved by currents in the lake. Since destruction of these drifts appeared to be one of the most logical means of control, a study on the effects of ovicides was made. A series of 900 tests were made in the laboratory during July, August, and September 1940 on oils, emulsions, organic ovicides, and combinations, to determine their toxicity to eggs that were floated on water in wide-mouth pint jars.

MATERIALS.—Kerosene, stove oil, diesel oil, and lubricating oils were tested. The lubricating oils had viscosities of S.A.E. 10 and 20. The other oils had the following specifications, which were furnished by the manufacturers:

	KEROSENE	STOVE OIL	DIESEL OIL
Flash point (Pensky Martens), °F.	136	132	188
Fire point (Cleveland), °F.	175	150	215
Viscosity at 100° F., Saybolt seconds	32	33	39
Distillation point, °F.:			
10 per cent	383	371	448
90 per cent	482	513	620
Water and sediment	0	Trace	Trace

The oils were emulsified with sodium oleate, liquid coconut-oil soap, fish-oil soap, and *Gardinol WA*. The sodium oleate emulsion contained 72.7 per cent of oil, 9.1 per cent of sodium oleate, and 18.2 per cent of water. The emulsions with coconut-oil soap (37 per cent) and fish-oil soap (40 per cent anhydrous soap) contained 10 per cent of soap, 80 per cent of oil, and 10 per cent of water. *Gardinol WA* was used at the rate of 1 per cent to 80 per cent of oil and 19 per cent of water.

Emulsions were prepared using 2 gallons of pyrethrum extract and oil 20 to 1, 1 gallon of water, and 8 ounces of liquid coconut-oil soap or *Gardinol WA* (U.S.D.A. Bureau of Entomology and Plant Quarantine 1938). Fish-oil soap and sodium oleate were also tried, but emulsions from these soaps broke down at concentrations of 1 to 10 with lake water. Emulsions from coconut-oil soap or *Gardinol WA* stood up well at concentrations of 1 to 20, and in some cases at lower concentrations a smooth spray was obtained, although frequent agitation was necessary.

Dinitro-o-cyclohexylphenol was tested in kerosene, stove oil, and diesel oil. *Pyagra* (0.7 per cent of pyrethrins in isopropyl alcohol) and nicotine sulfate was tested in various dilutions with water.

PROCEDURE.—Eggs were collected from the drifts in quart fruit jars as they occurred on the lake, and care was used in keeping them afloat. They were then transferred with a camel's-hair brush to wide-mouth pint jars containing 300 cc. of water. Usually no difficulty was experienced in getting the eggs to spread out in a thin film after they were floated on the surface of the water in the jars, in which they were to be sprayed.

The sprays were applied at rates of 0.2, 1, 2.5, and 5 cc. per jar by means of a small graduated vial with an atomizer operated by a hand bulb. Since a wide-mouth jar has an area of approximately 7 square inches, 0.2 cc. of ovicide per jar would be equivalent to 44.8 gallons per acre. This rate might at first appear unnecessarily high, but, considering that the egg drift is not stationary, one can see that it might be desirable to apply ovicides at even higher rates. A drift on the lake that initially covered 1 acre might easily concentrate into an area one-tenth that size.

After treatment the jars were kept at room temperature until the eggs had had sufficient time to hatch. Results of the tests were recorded from 20 to 24 hours after application. Egg counts were made and kills determined under the binocular microscope.

RESULTS.—The results are given in table 1. The lubricating oils are not listed, since they were ineffective.

Variation between tests made on different days and between eggs from different drifts in a few cases gave poor chi-square. Any wide deviation between tests run on

Table 1.—Effectiveness of the various materials as ovicides against the Clear Lake gnat.

Material	Concentration	Dosage per Jar, cc.	Number of Replications	Per Cent Mortality
Kerosene	—	5.0	6	3.9
		2.5	4	3.4
Stove oil	—	5.0	2	100.0
		2.5	6	99.4
		1.0	4	95.0
Diesel oil	—	5.0	2	97.5
		2.5	6	97.5
		1.0	4	84.7
Stove oil and fish-oil soap	8%	5.0	2	99.5
		2.5	6	99.4
		1.0	2	98.5
		.2	2	11.1
	4%	5.0	2	98.5
		2.5	4	99.3
		.2	2	0.0
Diesel oil and fish-oil soap	8%	2.5	5	96.5
		1.0	2	13.4
		.2	2	1.0
	4%	5.0	2	96.6
		2.5	2	93.8[1]
		2.5	2	41.0[1]
		1.0	2	12.3
Stove oil and *Gardinol WA*	8%	1.0	4	91.4
		.2	2	3.8
Diesel oil and *Gardinol WA*	8%	1.0	4	88.1
		.2	2	19.0
Kerosene-pyrethrum extract and coconut-oil soap	1–10	1.0	4	99.3
	1–20	1.0	6	99.4
		.2	6	81.3
	1–100	1.0	6	71.5
		.2	6	7.8
Stove oil-pyrethrum extract and coconut-oil soap	1–20	1.0	6	97.6
		.2	2	13.8
	1–100	1.0	4	74.0
		.2	4	10.5
Diesel oil-pyrethrum extract and coconut-oil soap	1–20	1.0	4	98.2[2]
		1.0	2	48.0[2]
		.2	4	17.2
	1–100	1.0	4	24.6
		.2	4	7.4
Kerosene-pyrethrum extract and *Gardinol WA*	1–10	1.0	2	97.6
	1–20	1.0	4	99.0
		.2	6	66.5
	1–100	2.5	6	89.5
		1.0	6	54.0
		.2	6	4.2
Stove oil-pyrethrum extract and *Gardinol WA*	1–20	1.0	4	97.3
		.2	6	80.1
	1–100	2.5	6	93.6
		1.0	6	87.4
Pyagra	1–100	1.0	2	100.0
		.2	2	94.8
	1–200	1.0	2	99.5
	1–400	1.0	4	97.1
		.2	4	35.6
Nicotine sulfate	1–100	1.0	2	76.1
		.2	2	40.7
	1–1000	2.5	2	5.2
		1.0	2	2.0
Dinitro-o-cyclohexylphenol in—				
Kerosene	0.5%	1.0	2	96.1
		.2	2	97.5
	0.25%	1.0	4	94.1
	0.1%	1.0	6	81.6
		.2	6	78.0
Stove oil	0.5%	1.0	4	99.2
		.2	6	99.7
	0.25%	1.0	2	100.0
		.2	2	100.0
Diesel oil	0.5%	1.0	4	99.6
		.2	6	96.0
	0.25%	1.0	2	100.0

[1] Variation due to scum of dead gnats and pupal skins being mixed with the eggs.
[2] First series of tests made at 11 A.M. and second series at 2 to 3 P.M. Also scum present.

eggs from different drifts was usually due to (1) time of application, (2) amount of scum, (3) uneven coverage caused by scum or insufficient spray, and (4) effect of lake water on a particular material applied.

Sodium oleate and coconut-oil soap gave such poor results with diesel oil and kerosene that only preliminary tests were made. Kerosene was very effective when used with pyrethrum.

DISCUSSION.—Eggs laid on the lake concentrate into compact drifts. A well-knit film is formed, which is not readily broken. Currents in the lake are continuously washing the under surface of the drifts and bringing in water free of toxic materials, especially when the egg film is held stationary by contact with the shore or vegetation near shore. Since the egg chorion splits on the side in contact with the water at the time of hatching, the emerging larvae would no doubt escape the effects of ovicides. Eggs in jars, with a scum as heavy as frequently occurs in the lake, will not hatch unless they are thinned or placed in fresh water. Surface and subsurface currents prevent stagnation of heavy drifts on the lake.

The eggs of the Clear Lake gnat were found to be fairly resistant to all the materials tested. Some of the sprays gave good kills under conditions where the egg films were clean of debris. These materials were not effective, however, when the eggs were partially protected by a scum of pupal skins and dead adults.

It was not determined how the mate-

rials destroyed the eggs. Powers & Headlee (1939) concluded that the eggs of *Aedes aegypti* (L.) are killed when coated with petroleum oil by oxygen starvation and that the more nearly perfect the oil coating the more quickly the kill is accomplished. They found no appreciable chemical reaction between the oil and the chorion or penetration of mosquito eggs by oil. If the same is true for *Chaoborus* eggs, then the pyrethrins evidently were capable of entering the shells, since the incorporation of pyrethrins with kerosene produced an effective spray.

Clear Lake is used extensively for recreational purposes; hence the use of ovicides containing a large percentage of oil would be objectionable. Furthermore, fish might suffer injury if subjected to appreciable quantities of toxic ingredients commonly used in sprays. The high concentrations and large amounts of material required to effect good kills make ovicides less promising as a control measure than burning with gasoline (Lindquist & Deonier 1942).—9-17-42.

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Further Tests with Thallium Baits for Control of the Fire Ant

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A discussion of the losses to quail in the Southeast occasioned by the fire ant, *Solenopsis geminata* (F.), and a report on the results of poisoned-bait tests against these insects have been published by the present writer (Travis 1938, 1939b). During March 1939 some additional field tests with poisoned baits were conducted on Forshala Plantation, near Tallahassee, Fla., at which time 595 colonies of fire ants were treated with syrup baits containing different proportions of thallium acetate and thallium sulfate. The poisons were all applied in a carrier which was composed of sugar, water, and cane syrup in the proportions of 16:16:1 by weight. Twenty grams of the bait were applied to each colony by one of the following methods: (1) In small aluminum bait cans buried in the colony mounds and covered with soil; (2) mixed with sawdust and placed on top of the mounds; and (3) mixed with excelsior and placed on top of the mounds. All colonies were treated that could be located in each of four blocks. The individual blocks were from 2 to 6 acres in size. These were thoroughly searched for ant activity, both at the time of treatment and at each subsequent examination.

COLONIES DESTROYED BY BAITS.—Observations at the time of treatment and again 3 days later showed that the ants fed rather freely on all the baits. Two weeks after the application of the baits, large numbers of dead and sluggish ants were noted in most of the colonies. Only a few appeared normal. Later examinations were made two months and 8 months after the baits were distributed, and the colonies which showed no activity were thoroughly excavated to determine whether any live ants remained.

The status of the experiments 2 months after treatment, as shown in table 1, indi-

[1] The writer acknowledges the cooperation and assistance of H. L. Stoddard and E. V. Komarek of the Cooperative Quail Study Association, and the managers of Forshala Plantation, for their cooperation during this experiment. Acknowledgment is also due G. H. Bradley and W. V. King for assistance and counsel in the preparation of this manuscript.

Table 1.—Per cent of fire ant colonies inactive 2 months after treatment with thallium baits and effect of method of application.

	THALLIUM ACETATE		THALLIUM SULFATE		BOTH
	Number of Colonies Treated	Per cent of Colonies Inactive	Number of Colonies Treated	Per cent of Colonies Inactive	Per cent of Colonies Inactive
Per cent of poison					
3.0	45	89	—	—	—
2.0	130	75	—	—	—
1.5	160	84	45	84	84
1.0	70	94	80	88	91
0.5	20	65	45	78	74
Method of application					
Cans	235	86	100	90	87
Sawdust	145	77	40	83	78
Excelsior	45	82	30	67	76
All tests	425	83	170	84	83

cated that of the 595 colonies treated, 494 or 83 per cent, were completely destroyed, and 52, or 8.7 per cent, of the colonies were partially destroyed. The remaining 8.3 per cent of the colonies appeared normally active. A slightly larger number of active colonies was recorded in an examination made 8 months after treatment, but the percentages were not materially changed. The percentages of colonies destroyed are based on the number of active colonies in the blocks, regardless of whether they were old or new.

The control obtained by the 1-per cent baits of both thallium acetate and thallium sulfate was slightly better than the control by baits of the other concentrations, and when the baits were applied in cans somewhat better results were obtained than when application was made with either sawdust or excelsior. When the data were analyzed for significance with the chi-square test for multiple degrees of freedom, it was shown that the 1-per cent and 3-per cent thallium acetate baits were superior to the other concentrations, but the differences for these two were not significant. There was no significant difference between the various concentrations of the thallium sulfate baits. Application by cans was significantly superior to the sawdust and excelsior methods.

REINFESTATION OF TREATED PLOTS.—The plots were examined 1 year after treatment to observe the degree of reinfestation. At this time there were some small changes in the percentages of inactive colonies, but the average for all tests of 83 per cent inactive colonies was the same as recorded at the observation 2 months after the treatment. There were, however, 346 colonies located in the blocks, as compared with 595 when the blocks were treated, which represents a reinfestation of 1 year equal to 58 per cent of the original population.

Reinfestation was due principally to migration and to the formation of new colonies in the blocks. A few of the colonies counted as reinfestations undoubtedly represent those overlooked when the poisons were applied, because the colonies frequently have long periods when no mounds are discernible at the surface of the ground.

The tests of 1938 and 1939 showed little evidence of the marked dispersal of the ant colonies which followed soil treatments with cyanide or other fumigants (Travis 1939a, 1940). Only 14 per cent of the 346 colonies in the treated areas were small, whereas in the case of the soil treatments the number of colonies frequently doubled, and most of these were very small.

DISCUSSION.—To obtain the best results with thallium baits, they should be applied in the spring when the top layers of soil are moist and warm, and the lower layers are still cool from the winter temperatures. At this time the ants congregate in the top several inches of the mound.

Although the use of bait cans gave somewhat better control, the use of sawdust with thallium poisons appears practical for field use because much less time is required for distributing the baits and

the cost of the containers is eliminated. This method, however, did not appear very promising with thallium sulfate when used late in the summer (Travis, 1939b). With thallium acetate at $20 and thallium sulfate at $10 per pound, the cost of applying the bait in cans was about 3.5 cents per colony for the thallium acetate and 2.5 cents when the thallium sulfate was used.

In the previous tests, which were conducted late in the summer (Travis 1939b), thallium acetate and thallium sulfate were applied in syrup baits both in the bait cans and soaked in sawdust; the acetate baits gave much better results than the sulfate. The ants did not accept the thallium sulfate when offered in syrup baits later in the summer, but did feed readily on syrup baits containing this poison when it was offered early in the spring. The syrup bait was a mixture of sugar, cane syrup, and water, similar to the one used in the present work.

Little difficulty was experienced with the application of the baits; however, some of the excelsior and sawdust baits were disturbed by migrating sparrows as they scratched in the ant mounds in search of stored seeds, and rodents and skunks carried off a few of the cans from the blocks that were located near cypress and gum swamps. In these cases the ants had consumed lethal amounts of the poisons before the baits were disturbed.

CAUTION.—Thallium is a powerful metallic poison, only slightly less poisonous than arsenic. It is distinctly accumulative in its effect and should be handled with special care. Thallium vapors given off while being heated also should be avoided.

SUMMARY.—Tests in northern Florida with different proportions of thallium acetate and thallium sulfate in syrup baits, applied to fire ant colonies in aluminum bait cans, in sawdust, and in excelsior, show that the best results were obtained with the 1-per cent baits when applied in bait cans. In tests with the 1-per cent baits, for all methods of application, thallium acetate destroyed 94 per cent, and thallium sulfate 88 per cent of the treated colonies. By the bait-can method of application 86 per cent of the colonies treated with all concentrations of thallium acetate and 90 per cent of those treated with thallium sulfate were destroyed. The bait-can method was found to be superior to either the sawdust or the excelsior method of application. Although slightly less effective than when applied in cans, thallium acetate applied by a sawdust method appears to have merit for field use, even though the results were slightly lower than by the can method, because much less time is required in distributing the baits and the cost of the container is eliminated.

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PACIFIC SLOPE BRANCH TO MEET

The 28th Annual Meeting of the Pacific Slope Branch of the American Association of Economic Entomologists will be held at Oregon State College in Corvalis, Oregon, on June 16, 17 and 18, 1943. The meeting will be held in conjunction with the Pacific Slope Division of the A.A.A.S. which is to hold meetings at the same place.

To date there has been no indication from the Office of Defense Transportation that there is any objection to the continuance of these meetings.

Toxicity of Cube-Vegetable Oil Dusts to Two Species of Aphids

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In the past few years certain research workers have found that rotenone sprays and dusts were more toxic to some species of insects when a vegetable oil was added. Richardson (1932) increased the effectiveness of a 0.02-per cent-rotenone spray against the common red spider, *Tetranychus bimaculatus* Harvey, by adding 0.5 to 1.0 per cent of sulfonated castor oil.

Fulton & Howard (1938) found that the toxocity of derris sprays to the squash bug, *Anasa tristis* (Deg.), and the large milkweed bug, *Oncopeltus fasciatus* (Dall.), was increased markedly by the presence of certain vegetable oils, namely, tung, teaseed, corn, peanut, olive, soybean, and linseed. Peanut oil proved to be the most effective.

In field experiments against the pea aphid, *Macrosiphum pisi* (Kalt.), Gray & Schuh (1940) demonstrated that a 0.75-per cent rotenone dust containing 4 per cent of vegetable or animal oil was superior to certain nicotine and pyrethrum dusts. These workers used the following oils: Cottonseed, castor, peanut, coconut, olive, and neat's-foot. They report no significant difference in the effectiveness among rotenone dusts containing these oils.

Ditman *et al.* (1940) and Bronson & Dudley (1940), in tests against the pea aphid, found that the addition of small amounts of peanut oil increased the effectiveness of derris dust.

Gambrell (1940) used soybean oil to enhance the toxicity of a derris spray to the larvae of the elm leaf beetle, *Galerucella xanthomelaena* (Schr.).

Johnson & Smith (1940) found that a rotenone-peanut oil spray was not very effective in controlling the gladiolus thrips, *Taeniothrips simplex* (Morison).

MATERIALS.—In the present investigation two species of aphids were used to determine the toxicity of cube dusts combined with certain vegetable oils. *Myzus persicae* (Sulz.) on turnip and *Aphis gossypii* Glov. on okra were collected from field infestations. Small leaves, bearing from 50 to 100 mature aphids, were taken to the laboratory, and predators and parasitized aphids were removed. During the experiments certain aphids proved to be parasitized but, fortunately, parasitization did not exceed 5 per cent in any test.

The undiluted cube contained 4.2 per cent of rotenone and 14.2 per cent of total extractives. The dust mixtures were made up to contain 0.25 per cent of rotenone, or one-third the strength recommended for practical purposes, in order to give mortalities below 100 per cent. The vegetable oils were used at a concentration of 1 per cent. All oils were in a natural form. In certain mixtures, sodium oleyl sulfate was incorporated as a conditioning agent. The inert ingredient was talc.

Two nicotine dusts were tested to aid in the evaluation of the cube. Both were prepared from nicotine sulfate (40 per cent) and hydrated lime to give concentrations of 0.67 and 1.33 per cent of nicotine, or one-third the strengths used in the field.

One dust, which was used only on *Myzus persicae*, contained cube, tobacco dust, and sulfur. The active ingredients were used at one-third the strengths recommended by Allen & Harrison (1941).

METHODS.—A leaf was placed lower side up on a dusting stand in such a way that the aphids would be exposed to falling dust particles. A battery jar was placed over the leaf. Dust was blown into the jar at an air pressure of 10 pounds per square inch. One minute was allowed for the dust to settle. The stem of the leaf was placed immediately into a vial of water and, with the dusted side down, the leaf was laid horizontally on a piece of blotting paper in a large Petri dish. A cheese-cloth-covered embroidery hoop was placed over the dish to retain the aphids and yet allow for aeration. The treated leaves were removed to a controlled cabinet, which was set to maintain a temperature of 70° F. and 50 per cent relative humidity. The aphids remained there for 2 days.

[1] Agent, Bureau of Entomology and Plant Quarantine, summer of 1940.

Table 1.—Toxicity of various contact dusts to two species of aphids.

Active Ingredients in Dust	*Myzus persicae* on Turnip			*Aphis gossypii* on Okra		
	Number of Insects	Dosage, Micrograms per Sq. Mm.	Percentage Mortality after 2 Days	Number of Insects	Dosage, Micrograms per Sq. Mm.	Percentage Mortality after 2 Days
Rotenone 0.25%	55	0.66	12.7	42	0.33	28.6
	77	1.27	13.0	86	0.56	15.1
	52	1.67	30.8	49	0.58	22.4
	52	2.03	40.4	80	0.61	31.4
	105	2.06	29.5	67	1.16	25.4
	80	2.43	45.0	51	1.87	70.6
				55	1.92-	54.5
				64	2.13	53.1
Rotenone 0.25%, peanut oil 1%	53	0.71	26.4	46	0.32	19.6
	24	0.96	45.8	38	0.61	42.1
	47	1.47	48.9	64	0.74	28.1
	71	2.13	74.6	60	0.87	41.8
	48	2.18	54.2	62	1.57	48.4
	63	2.33	55.6	79	1.72	50.6
				53	2.08	83.0
				56	2.33	67.9
Rotenone 0.25%, grapefruit seed oil 1%	46	0.66	15.2	102	0.28	24.5
	62	1.01	38.7	39	0.56	34.1
	57	1.72	49.1	66	0.58	28.8
	44	1.87	72.7	75	0.61	46.7
	46	1.95	43.5	75	1.11	40.0
	88	2.43	81.8	72	1.62	47.2
				94	1.97	89.4
				61	2.18	63.9
Rotenone 0.25% soybean oil 1%	45	0.66	26.7	61	0.33	24.6
	62	1.24	45.2	102	0.58	32.3
	79	1.75	51.9	54	0.60	20.4
	60	1.97	56.7	49	0.61	58.1
	61	2.03	49.2	81	1.06	50.6
	64	2.63	85.9	80	1.37	53.7
				109	1.52	73.4
				102	2.03	93.1
Rotenone 0.25%, olive oil 1%	35	0.56	17.1	46	0.40	15.2
	55	1.24	36.4	45	0.63	40.0
	59	1.57	39.0	53	0.67	34.0
	48	1.82	56.2	64	0.71	45.4
	47	1.97	59.6	116	1.16	38.8
	77	2.18	79.2	99	1.47	46.5
				136	1.92	69.1
				75	2.28	78.7
Rotenone 0.25%, sodium oleyl sulfate 1%, water 2%	105	0.71	16.2	71	0.35	12.7
	48	1.22	39.6	113	0.68	28.3
	63	1.87	33.3	47	0.70	12.8
	55	1.92	23.6	92	0.71	44.2
	49	2.18	57.1	119	1.37	33.6
	70	3.19	65.7	112	1.52	36.6
				71	1.67	60.6
				36	2.08	86.1
Rotenone 0.25%, peanut oil 1%, sodium oleyl sulfate 1%, water 1%	51	0.61	29.4	56	0.40	17.8
	60	1.22	43.3	60	0.68	31.7
	41	1.62	46.3	40	0.80	32.5
	58	1.72	48.3	66	0.81	40.8
	55	2.40	49.1	64	1.37	48.4
	61	3.04	55.7	113	1.47	41.6
				78	1.98	71.8
				62	2.03	91.9

Table 1.—(Concluded)

Active Ingredients in Dust	*Myzus persicae* on Turnip			*Aphis gossypii* on Okra		
	Number of Insects	Dosage, Micrograms per Sq. Mm.	Percentage Mortality after 2 Days	Number of Insects	Dosage, Micrograms per Sq. Mm.	Percentage Mortality after 2 Days
Nicotine 0.67%	61	0.56	8.2	112	0.20	2.7
	113	0.76	0.0	70	0.38	11.4
	73	1.01	5.5	53	0.47	15.1
	98	1.11	10.2	71	0.56	10.3
	89	1.24	14.6	39	0.96	15.4
	67	1.42	26.9	44	1.01	11.4
				95	1.27	21.0
				87	1.42	29.9
Nicotine 1.33%	58	0.53	17.2	146	0.25	8.9
	55	0.76	20.0	32	0.56	21.9
	70	1.01	14.3	107	0.81	14.9
	57	1.06	26.3	108	0.86	29.6
	72	1.11	19.4	22	1.01	18.2
	43	1.47	20.9			
Rotenone 0.33%, tobacco dust 16.67%, sulfur 16.67%	52	0.58	28.8			
	73	1.22	34.2			
	51	1.27	31.4			
	105	1.52	27.6			
	53	1.94	58.5			
	49	2.53	55.1			

The dosage of dust per unit area was determined by weighing the dust deposit on a microscope slide placed beneath the dusting jar with the infested leaf. Factors, such as type of carrier, static electricity, and volume of dust discharged made it preferable to correlate mortality with the dust actually falling to the base of the dusting jar.

Results and Discussion.—The effectiveness of the dusts was determined on examination of the aphids at the end of the holding period. The response of the aphids, when stimulated with a probe, was used as the criterion of toxicity. The aphids unable to walk were included with those that were apparently dead. The results were taken only on mature aphids. Untreated aphids, which were included in each experiment, indicated no mortality due to technique or other causes exclusive of parasitization. The experimental data are presented in table 1.

After the method of Bliss (1938), the data were fitted to linear regressions. This statistical method, which involves using the log-probit curve, was used because it takes into account the greater variation encountered with a limited number of trials. The median lethal dose and its standard error, adjusted for the 5-per cent level, and the slope of the regression line, together with its standard error, were calculated and appear in table 2. To measure the agreement of the observed values with the expected values the chi-square test was used for each set of data. Many of the chi-square values are larger than would be expected to occur by chance ($P = .05$). More intensive analysis of the data might have reduced the estimate of variability somewhat. When the median lethal doses were obtained by extrapolation, the standard errors were not computed, as the upper limit of these errors would be beyond the range of the observed data. Tests of significance were accordingly limited to the median lethal doses for which errors had been computed.

Under the conditions of these experiments, the toxicity of cube is enhanced upon the addition of peanut, grapefruit-seed, soybean, or olive oil. Sodium oleyl sulfate increased the effectiveness of cube slightly. There was no gain in efficiency of the cube-peanut oil dust when sodium oleyl sulfate was added. The cube-tobacco dust-sulfur mixture had toxic properties similar to those of the 0.25-per cent rotenone dust against *Myzus persicae*.

The two nicotine dusts were not so effective as cube, but the data are insufficient for definite conclusions. The nicotine caused an immediate knock-down, but in

Table 2.—Statistical constants derived from the data in table 1.

Active Ingredients in Dust	Median Lethal Dose $\pm 1.96^{3}s_x$ Micrograms per Sq. Mm.		Slope of Regression Line		Chi-Square	
	Myzus persicae	*Aphis gossypii*	*Myzus persicae*	*Aphis gossypii*	*Myzus persicae*	*Aphis gossypii*
Rotenone 0.25%	2.68[1]	1.76 ± .50	2.32 ± .44	1.35 ± .46	7.71	30.59
Rotenone 0.25%, peanut oil 1%	1.45 ± .29	1.23 ± .23	1.72 ± .39	1.53 ± .38	9.74	17.98
Rotenone 0.25%, grapefruit seed oil 1%	1.45 ± .17	0.96 ± .20[1]	2.88 ± .66	1.18 ± .41	16.53	40.19
Rotenone 0.25%, soybean oil 1%	1.48 ± .21	0.85 ± .09	2.19 ± .58	2.38 ± .50	12.97	39.14
Rotenone 0.25%, olive oil 1%	1.52 ± .17	1.18 ± .16	2.86 ± .60	1.74 ± .35	10.41	17.22
Rotenone 0.25%, sodium oleyl sulfate 1%, water 2%	2.41 ± .49	1.62 ± .32	1.89 ± .51	1.60 ± .58	16.39	45.00
Rotenone 0.25%, peanut oil 1%, sodium oleyl sulfate 1%, water 1%	2.12 ± .86	1.19 ± .14	0.91 ± .32	2.23 ± .53	0.40	31.31
Nicotine 0.67%	2.80[1]	4.91[1]	2.95 ± .96	1.26 ± .24	12.98	6.58
Nicotine 1.33%	[2]	4.29[1]	[2]	1.08 ± .32	[2]	7.11
Rotenone 0.33%, tobacco dust 16.67%, sulfur 16.67%	2.66[1]		1.19 ± .56		12.85	

[1] Extrapolated.
[2] Results very inconsistent.
[3] The statistical constant used to change odds from 2 out of 3 to 19 out of 20. See Bliss, 1938.

2 days most of the aphids recovered. Conclusions as to the relative efficacy of nicotine dust at one-third the strength recommended for field use, as compared with cube dust at similar dilution, may not be valid for stronger mixtures.

Myzus persicae appeared to be more resistant to the dusts than *Aphis gossypii*.

SUMMARY.—On the basis of the median lethal dose, cube-talc dust (0.25 per cent rotenone) proved significantly more toxic to *Aphis gossypii* on okra in laboratory experiments when combined with 1 per cent of grapefruit-seed oil or soybean oil than when used alone. Likewise, the addition of 1 per cent of peanut oil or olive oil increased the effectiveness of the dust, but the differences were not significant.

In tests with *Myzus persicae* on turnip, the medial lethal dose of cube-talc dust appeared to be decreased by the addition of conditioning agents. However, the median lethal dose for unconditioned cube-talc was obtained by extrapolation, and consequently the values cannot be compared for significance.—6-23-42.

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Increases in Aphid Populations on Potato Plants Sprayed with Zinc Arsenite in Western Nebraska[1,2]

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During the 1941 growing season, field observations in western Nebraska indicated that aphids, *Myzus persicae* (Sulz.), were becoming abundant in experimental potato plots that had been treated with zinc arsenite-lime sulfur spray for controlling potato flea beetles, *Epitrix cucumeris* (Harr.), and the potato psyllid, *Paratrioza cockerelli* (Sulc.). Detailed examinations of leaves showed that significantly greater populations were present on the sprayed than on the untreated plants. Evidence of slight increases also was noted on plants dusted with a barium fluosilicate and sulfur mixture.

In western Nebraska zinc arsenite-lime sulfur sprays are widely used to combat potato insects. Since there is a large acreage of potatoes grown with a view to certification for seed purposes in this area, control measures that tend to increase aphids might have important economic implications because of their role in the dissemination of virus diseases. Consequently, in 1942 additional investigations were undertaken in an effort to determine more clearly the effects of different treatments on the aphid populations. It is the purpose of this paper to present briefly the results obtained regarding this phenomenon during 1941 and 1942.

LITERATURE REVIEW.—A number of workers have observed that the application of certain insecticides to plants results in an increased aphid population. Folsom published information in 1927 showing that populations of *Aphis gossypii* Glov. were much greater on cotton plants treated with calcium arsenate than on untreated plants. Additional evidence on this problem has been published by Gaines *et al.* (1940, 1941), Bibby (1942) and Smith & Fontenot (1942). McGarr (1941) and Gaines (1941) both report that cryolite-sulfur dusts increased the aphid population somewhat but considerably less than calcium arsenate. Moore (1937) found that *Brevicoryne brassicae* (L.) was more abundant on cabbage plants dusted with lead arsenate and lime than on untreated plants. Taylor & Blodgett (1930) and Nottingham & Rawlins (1941) reported marked increases in aphid populations following spraying of potato plants with bordeaux mixture. This phenomenon likewise has been observed by a number of other investigators, not only in connection with aphids but also in the case of certain other insects and mites.

MATERIALS AND METHODS.—The insecticides used were zinc arsenite and barium fluosilicate (*Dutox*), both commercial products. According to the analysis on the container, the zinc arsenite used in 1941 contained 30.5 per cent metallic arsenic (equivalent to 40.3 As_2O_3) and had a water soluble arsenic content of 0.42 per cent. The 1942 sample showed the same analysis except that the water soluble arsenic content was guaranteed to be not more than 1 per cent. As shown on the label, the *Dutox*, here-in-after referred to as barium fluosilicate, contained 72 per cent barium fluosilicate and 8 per cent sodium fluoaluminate. Usually the zinc arsenite was applied at a concentration of 2 pounds to 40 gallons of spray to which 1 gallon of liquid lime sulfur was added. However in one instance a concentration of 1 to 40 was used, and in another wettable sulfur (1–10) was substituted for the lime sulfur; in 2 cases zinc arsenite was used without the addition of sulfur. Barium fluosilicate was used as a dust, prepared by adding 1 part of barium fluosilicate to 4 parts (by weight) of dusting sulfur and in experiments 6 and 7 (Table 2) a dilution of 1 to 8 was also tested. Since an analysis of the data showed that under the conditions of these tests the sulfur did not have a significant effect on the aphid population either alone or in combination with zinc arsenite or barium fluosilicate, further reference to this material is omitted from the discussion.

Sprays were applied at the rate of about 125 gallons per acre and dusts at approximately 35 pounds per acre. The treatments, which varied from 1 to 4, were made between July 6 and August 23. All spray applications were made with power

[1] Contribution from University of Nebraska Agricultural Experiment Station. Journal Series No. 328.

[2] Early publication of this paper has been secured by the payment of the cost of printing.

equipment at approximately 300 pounds pressure. In experiments 1, 2 and 3 (Table 2) the dusts were applied with a rotary hand duster but in all others a 4-row power machine equipped with a short apron was employed.

Throughout the 1942 growing season aphid collections were made in four different experimental fields in order to determine the seasonal population trend. A 15-inch insect net was used at intervals of from 3 to 5 days and either 50 or 100 sweeps were taken in the center rows of each replicate.

Late in the season (during the second and third weeks in September) total aphid population counts were made on 25 to 50 leaves from each replicate of both treated and untreated plots in 8 different fields. Two leaves were selected from a plant, both from the lower level of growth, at about 15-foot intervals in the center rows. Both the plants and the leaves were selected at random, an objective which was facilitated by the abundance of foliage present at that time. The experiments (Table 2) may be briefly described as follows: No. 1, 6-row plots 200 feet long, 2 replicates; No. 2, 12-row plots 600 feet long, 2 replicates; No. 3, 4-row plots 250 feet long, 2 replicates; No. 4, 4-row plots 400 feet long, 2 replicates; No. 5, 4-row plots 400 feet long, 4 replicates; No. 6, 20-row plots 270 feet long, 2 replicates; No. 7, 20-row plots 250 feet long, 2 replicates; and No. 8, 12-row plots 350 feet long, 2 replicates. The first 3 experiments were conducted in 1941 and the last 5 in 1942. Additional details are given in table 2.

RESULTS.—In table 1 a summary of data obtained in a number of different irrigated potato fields shows the seasonal trend of aphid populations, as determined by sweeping with an insect net, on untreated plants, plants sprayed with zinc arsenite, and plants dusted with barium fluosilicate. Although a number of different species of aphids were collected, the principal one, and the only one that occurred in significant numbers at any time, was *Myzus persicae*. The aphid populations, in both the treated and untreated plots remained at a very low level, as shown in table 1, until the latter part of August. Following this there was a marked increase which continued until freezing temperatures occurred. The rate of increase was much greater on the plants treated with zinc arsenite, and in 1942 when the last sweepings were made on September 16 the population had increased to an average of 1290 per hundred sweeps, or approximately 40 times that in the checks. The data in table 1 indicate that barium fluosilicate had no appre-

Table 1.—Seasonal trend of aphid populations as shown by sweeping untreated potato plants and plants treated with either zinc arsenite[1] or barium fluosilicate[1] in irrigated fields at Scottsbluff, Nebraska, in 1942.

Collection Dates	Zinc Arsenite[2]		Untreated[2]		Barium Fluosilicate[3]		Untreated[3]	
	Total No. sweeps	Ave. No. 100 sweeps	Total No. sweeps	Ave. No. 100 sweeps	Total No. sweeps	Av. No. 100 sweeps	Total No. sweeps	Av. No. 100 sweeps
July 17–21	450	0.2	150	0.0	100	0.0	50	0.0
23–27	550	0.5	250	1.2	300	0.0	150	0.0
28–29	700	1.0	350	0.3	600	1.8	300	0.3
31–Aug. 2	900	5.7	400	6.2	600	4.2	300	8.7
Aug. 3–7	1350	5.6	650	11.4	1100	4.0	550	10.0
9–12	750	0.4	400	0.0	700	0.1	350	0.0
13–15	700	0.1	350	0.3	600	1.0	300	0.7
17–18	700	1.4	350	3.7	600	0.5	300	2.0
20–23	750	8.7	400	1.5	700	1.0	350	0.6
26–Sept. 1	750	27.7	400	7.5	700	5.4	350	7.1
Sept. 2–8	700	76.1	350	9.7	600	8.2	300	9.0
10–16	700	1290.0	350	32.6	600	19.5	300	18.7

[1] Plants treated from 2 to 4 times between July 6 and August 23.
[2] Zinc arsenite data based on samples taken from 10 replications in 4 different fields; data on untreated plants based on samples taken from 5 replications in same fields.
[3] Barium fluosilicate dust data based on samples taken from 8 replications in 3 different fields; data on untreated plants based on samples taken from 4 replications in the same fields.

ciable effect on the aphid population.

Data on the results of a total aphid count on leaf samples from 8 separate field experiments are shown in table 2. Each treatment was compared with the accompanying check by means of the "t" test. On the basis of these comparisons all 12 treatments which involved two or more applications of zinc arsenite showed a highly significant aphid population increase. In one instance (experiment 4) there was no increase on plots receiving a single application of zinc arsenite; in another (experiment 5) one application resulted in a significant increase as compared to a highly significant increase in the same experiment where two and three applications were made.

Although barium fluosilicate resulted in highly significant population increases in two fields (experiments 2 and 6), the average population per leaf was only about a fourth to a half as great as for zinc arsenite in the same experiments. In one field (experiment 3) a significant increase occurred, but again the population was only about one-half as great as for zinc arsenite under the same conditions. In four other instances (experiments 1, 2, 6 and 7), significant increases did not occur on barium fluosilicate treated plots, whereas in the same experiments there were highly significant increases in plots treated with zinc arsenite.

DISCUSSION.—On the basis of the above data it may be concluded that, under the conditions of these experiments, highly significant aphid population increases occurred on plants treated with zinc arsenite spray, especially when two or more applications were made. Some increase seemed evident on plants treated with barium fluosilicate, but the increase was relatively minor when compared with zinc arsenite.

Although these increases might not be of any particular significance in fields grown for table stock, the very low tolerances for virus diseases in certified potatoes makes any increase in the number of vectors a matter of great importance. In some localities of western Nebraska, potato growers have encountered increasing difficulty during the last few years in producing certified seed because of the presence of mosaic. More recently, leaf roll has become of importance in certain localized areas. These observations indicate that the control of virus diseases transmitted by aphids may become more difficult due to the use of zinc arsenite for controlling flea beetles.

Control of the aphids by means of nico-

Table 2.—Aphid populations on leaf samples from untreated plots and plots treated with either zinc arsenite spray or barium fluosilicate dust in irrigated potato fields in western Nebraska—1941 and 1942.

TREATMENT[1]	NO. APPLICATIONS	AVERAGE APHIDS PER LEAF	"t" VALUES[2]
Experiment 1—(40 leaf samples)			
Untreated	—	6.15	—
Zinc arsenite	3	48.40	5.28**
Barium fluosilicate	3	6.05	0.01
Experiment 2—(40 leaf samples)			
Untreated	—	6.15	—
Zinc arsenite	3	55.20	7.64**
Zinc arsenite[3]	3	57.50	7.72**
Barium fluosilicate	3	13.40	4.42**
Barium fluosilicate[4]	3	9.17	1.92
Experiment 3—(30 leaf samples)			
Untreated	—	3.40	—
Zinc arsenite	3	11.00	4.90**
Barium fluosilicate	3	5.76	2.15*
Experiment 4—(50 leaf samples)			
Untreated	—	3.54	—
Zinc arsenite	1	4.44	1.35
Zinc arsenite[5]	3	24.06	4.36**
Experiment 5—(50 leaf samples)			
Untreated	—	2.97	—
Zinc arsenite	1	5.38	2.39*
Zinc arsenite[5]	2	11.82	6.60**
Zinc arsenite[5]	3	14.88	6.80**
Experiment 6—(50 leaf samples)			
Untreated	—	1.92	—
Zinc arsenite	4	8.26	5.03**
Barium fluosilicate	4	4.46	3.30**
Barium fluosilicate (1–8)	4	2.62	1.23
Experiment 7—(25 leaf samples)			
Untreated	—	5.68	—
Zinc arsenite	2	9.52	2.91**
Barium fluosilicate	2	4.40	1.12
Barium fluosilicate (1–8)	2	5.88	0.15
Experiment 8—(50 leaf samples)			
Untreated	—	5.7	—
Zinc arsenite[6]	4	74.0	6.26**
Zinc arsenite	4	102.7	4.84**
Zinc arsenite (1–40)	4	14.6	5.24**

[1] Unless otherwise specified, zinc arsenite applied as spray 2 pounds to 40 gallons of water plus 1 gallon liquid lime sulfur; barium fluosilicate (*Dutox*) used as dust 1 to 4 (by weight) of 300 mesh dusting sulfur.
[2] Treatments compared with check for "t" values.
[3] Three pounds wettable sulfur in place of lime sulfur.
[4] *Electric* dusting sulfur as carrier.
[5] No sulfur added.
[6] Zinc arsenite-lime sulfur plus 0.5 pound wheat flour
* Significant difference (P = 0.05).
** Highly significant difference (P = 0.01).

tine, rotenone or other aphicides presents some complications in view of the fact that the population build-up occurs later in the season (after regular spraying operations have been completed) and when spraying or dusting machinery would cause serious damage to the plants. In field tests conducted during the last 3 years in western Nebraska (unpublished data) barium fluosilicate dust was as effective as zinc arsenite spray in controlling the potato flea beetle. These results combined with the fact that relatively minor aphid population increases occurred on plants treated with barium fluosilicate indicate that substituting this material for zinc arsenite might contribute toward a solution of the problem.

SUMMARY.—Significant increases in aphid populations were found in experimental fields as well as in commercial plantings where zinc arsenite was used for control of the potato flea beetle, especially when two or more applications were made.

Although population increases sometimes occurred following the use of barium fluosilicate dust, these increases were slight as compared to zinc arsenite. In a majority of the tests no significant increases were found where barium fluosilicate was used.

Aphid collections on late plantings, which comprise the principal crop in western Nebraska, showed that populations remained at a low level on both treated and untreated plants until late August or early September.

The direct control of aphids with insecticides in this area would be complicated by the fact that the population increases occur late in the season when the use of machinery would cause serious damage to the vines. The use of barium fluosilicate dust, which is as effective as zinc arsenite for the control of flea beetles, may offer one solution of the problem.—1-11-43.

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DR. RICHARDSON BECOMES ASSISTANT EDITOR OF CHEMICAL ABSTRACTS

Dr. C. H. Richardson of Iowa State College, has been appointed an assistant editor of *Chemical Abstracts* in charge of Section 11-1-Zoology, to fill the place made vacant by the recent death of Dr. Ross A. Gortner. Section 11-1 contains abstracts of many papers on the physiology of insects besides abstracts of papers on other invertebrates and on vertebrate animals. The appointment comes as a reward for more than 20 years of abstracting entomological and zoological literature for *Chemical Abstracts*.

Sodium Fluoride Crayons for Roach Control[1]

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Sodium fluoride (NaF) and mixtures of NaF and pyrethrum powder are commonly used by the housekeeper and pest control operator for the control of the German cockroach, *Blatella germanica* (L.). The powder is sprinkled crudely or distributed by means of rubber bulb applicators or power dusters in or about the hiding places of the insects. Although thorough dusting of NaF usually results in satisfactory control, its use in this way is often objectionable, particularly in places most frequented by the German roach; viz., kitchens and restaurants, where it may contaminate food or utensils.

It occurred to Mr. H. E. Jennings of the *Smithereen Co.* that the efficiency of NaF application might be increased and the hazards reduced by making sticks or crayons of NaF, like sticks of chalk, by means of which "deadlines" could be laid down in the proper places. The present paper deals with the development and practical trials of a product[2] based on this idea.

THE PROBLEM OF CRAYON APPLICATION.—An ideal line left by a stick of sodium fluoride would kill every roach that crossed it once. In preliminary tests adult male German roaches were caused to run across a plate covered with a uniform deposit of NaF laid down in a dust tower. Observations indicated that contact with the powder was made only by the tarsi, which left well-defined foot prints of the roach in the dust. Shortly after crossing the dusted surface, the roach hurriedly cleaned the tarsi with its mouth parts. Shafer (1915), Hockenyos (1933), and Munger & Siegler (1937) have shown that NaF acts both as a contact and stomach insecticide against roaches. However, in the present experiments the test insects could not have been killed by contact action of the minute quantity of NaF remaining on the tarsi after they had been cleaned. Therefore, the present lethal effect of NaF is attributed to its action in the alimentary tract.

If the tarsi of a roach picked up more than 0.3 mg. of NaF in crossing a deposit of powder, it was almost certain to die, whereas quantities less than 0.1 mg. were seldom fatal. Further, increasing the depth or width of the deposit resulted in an increase in the mortality. Oil was added to the powder in an attempt to increase the quantity adhering to the tarsi. Of a series of oiled dusts containing from 1 per cent to 10 per cent by weight of number 30 S.A.E. motor oil, 6 per cent oiled dust was shown to be the most effective. In comparison with unoiled NaF, a deposit 6.4 cm. wide of 6 per cent oiled dust required approximately half the quantity of powder for the same degree of effectiveness when crossed only once by the roaches. However, even the quantity of oiled dusts needed to introduce a satisfactory kill with one crossing of a dusted surface was in excess of that which could be left by a chalk mark of practical width; *e.g.*, 3.7 cm.

The failure of a narrow band of NaF dust to kill every roach that crossed it once did not exclude stick application as a practical control measure, if the roaches were likely to cross the thin deposit several times. Small quantities of moist NaF pounded into crayons in a metal tube and then dried were used to mark lines across the bottom of cockroach rearing drawers containing from 60 to 100 unselected roaches. Food and water were placed on one side of a single line drawn in each drawer and corrugated cardboard strips, serving as shelters, on the other side. A line drawn directly on the unvarnished rough bottom left a heavy deposit and in most cases more than 95 per cent of the roaches died within 24 hours after the application. A much lighter line drawn on a strip of cellulose acetate (celluloid) tacked across the bottom was less effective, although it was tracked up quickly and completely. Although dust deposits of 6 per cent oiled dust laid down by means of a dust tower were more effective than unoiled dusts, the latter worked more efficiently in crayons because the oil interfered with the deposition of the powder.

MAKING CRAYONS.—Using a brass tube three-fourths inch in diameter as a mold,

[1] Contribution of the Ohio State University Research Foundation in cooperation with the Smithereen Co., Chicago, Ill. Project supervised by Professor F. L. Campbell.

[2] Patent pending; assigned to H. E. Jennings. It is not on the market at present.

wet commercial NaF was pressed into sticks or rods. From 100 grams of NaF about six 2.25-inch crayons were made. While drying, the surface became hard, but the core remained soft and readily left a deposit like a chalk mark on all but polished surfaces. In the tests reported here, two coats of transparent lacquer were applied to each crayon to strengthen it. Later, the lacquer treatment was discontinued and structural strength was increased by heating the crayon immediately after it was formed in a hydraulic press.

PRACTICAL APPLICATIONS.—Preliminary treatments of an artificially infested room indicated that crayon applications would be safe and effective. A heavily infested restaurant kitchen, a grocery store, and an apartment were then selected for practical tests of the effectiveness of this method in controlling the German roach.

In the restaurant a solid line of NaF was drawn on the floor next to the walls, entirely around the kitchen. By rubbing the crayon back and forth along the wall the powder was made to sift down behind radiators, into cracks in the molding, into wash basins, and into places otherwise inaccessible. The sifting powder tended to cling close to the wall as it fell. The corners beneath table tops were marked as well as the top inner borders of shelves used for storing foods. The plumbing fixtures beneath basins and wash tubs were heavily marked. No attempt was made to clean up piles of long-accumulated filth beneath tables, lockers and stoves. Instead, lines were drawn bordering such dirty places. In no case were applications made directly over open foodstuffs or utensils. Eight crayons were used in the treament applied between 11 P.M. and 1 A.M.

The grocery store treated possessed a far heavier infestation than the restaurant kitchen. Empty egg capsules, cast skins, and cockroach droppings were to be found in almost every corner and under every box or movable object examined. The grocers reported that roaches were seldom noticed in the front part of the store, and for this reason applications were confined to the rear sections. A single heavy line was drawn on the floor about the base of each show case and counter. All corners of a wooden support for a false wall back of the meat counter were treated. Powder was sifted behind the refrigerator as previously described, and into cracks where the molding had separated from the wall. Lines were drawn around the openings that led to the basement, around water fixtures of all sorts, behind shelves, along the ceiling molding, in the bottom of show cases, and in other places where there was evidence that the roaches had been active. Twelve crayons were used in 2 hours.

The apartment treated was located above the infested grocery. Applications were made in the late evening in the kitchen and bathroom. The entire base of the molding was marked as well as the floor along the molding. A single line was drawn surrounding each register. Marks were made along the edges of the cupboard and along the cracks where the window frames joined the wall. On the upper inside borders of each cupboard shelf a single heavy line was drawn, and the corners beneath each shelf were thoroughly marked. Less than 4 crayons were required for the treatment.

In the basement of the grocery many roaches of all stages were found swarming over a cement wall in the vicinity of a drain, which was evidently their water supply. Four horizontal lines were drawn at different levels across the wall for the entire length of the roach-covered area. Two vertical lines were then drawn connecting the ends of the horizontal lines. During the application much of the powder sifted down the sides and formed a heavy deposit of dust at the junction of the floor and wall.

RESULTS.—The writer's observations are supplemented with comments by cook, grocer, tenant, and landlord.

A number of dead adult roaches, including females bearing egg capsules, were found about the floor on the restaurant kitchen 24 hours after the application. Beneath the chalked inside corners of table tops dead nymphs were found in groups of 4 to 9. Roaches had disappeared from the corners and cracks that had been crowded with them before the treatment. A number of live roaches were found in piles of dirt, but they moved slowly.

The following day the cook said that the infestation had become worse since the application was made, and complained that the roaches were continually

falling off the ceiling. Two weeks later she seemed favorably impressed with the results, because she had not found it necessary to spray since the second day following the application, whereas she had previously sprayed every other night.

Ten hours after the grocery store was treated, a few dead roaches were found on the floor in the front of the building where live roaches had seldom been noticed by the store attendants. The following day the number dead had greatly increased, one clerk having counted 25 upturned roaches behind a single counter. Living roaches were not found in any of the corners marked with NaF.

Ten days after the application all the original marks were still present, as the storekeeper had been careful not to sweep the lines away. A few live roaches were then found by carefully searching behind shelves of canned foods, but the treatment continued to function; each morning a number of dead roaches were swept up. The live roaches were thought to have come from the kitchen of an untreated adjoining shop in which the landlord lived. He reported that shortly after the application next door his kitchen was overrun with roaches, but that they moved slowly and were easily killed. Later he noticed fewer roaches than before the neighboring treatment.

During the first two nights after treatment of the upstairs apartment, the tenant also complained that roaches had dropped about her from the ceiling of the kitchen. The night following the application, 18 dead roaches were taken from one cupboard. Three days later the tenant reported that roaches were on their backs all over her kitchen. On the second evening after the treatment, the writer saw a few live roaches crawling about on the walls. An inspection of the original marked hiding places did not reveal the presence of a single roach.

At the base of the wall surface treated in the cellar, more than 200 dead roaches, in all stages, were found 24 hours after application. No live roaches were to be seen throughout the treated area.

DISCUSSION.—Application of NaF by the use of crayons increases its efficiency and safety for the control of German roaches. Lines may be easily drawn on surfaces, such as walls and ceilings, which are difficult or impossible to treat satisfactorily by prevailing methods. When carefully applied, there is no danger that dust from a stick will settle upon food or utensils. Except for the insects hiding in cracks into which the powder sifts, the roaches do not as a rule become covered with the dust. This lessens the danger of contaminating food or utensils over which the roaches may run after coming into contact with the poison.

If the marks are not disturbed, they will function for an indefinite period of time and offer protection against reinfestation. The marks made along the ceiling molding in the grocery store remained visible for at least 7 months. Stick marks are neat in appearance, but, if desired, may be easily removed from all surfaces by gently wiping them with a damp cloth.

The sticks may be colored to make the deposits less conspicuous. The addition of colored or distasteful substances in or on the sticks may serve to warn the user that they are not innocuous.

By use of crayons maximum results are obtained with minimum expenditure of material—a particularly attractive feature at present.

The tendency of the crayon treatment to cause roaches to drop from overhead or wander into new surroundings is not peculiar to the use of crayons, but would result from any thorough application of NaF.

SUMMARY.—Wet sodium fluoride can be molded and dried in the form of sticks or crayons which will mark most surfaces like chalk. Such marks or lines applied on infested surfaces will control the German cockroach. Practical applications in a roach-infested restaurant kitchen, a grocery store, and an apartment proved to be effective, safe, convenient, and economical,—a distinct improvement over prevailing methods of application.—10-28-42.

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Soybean Phosphatides as Deposit-Builders in Nicotine Bentonite and Lead Arsenate Spray Mixtures for Control of the Codling Moth

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Promising results obtained in preliminary experiments with soybean phosphatides as deposit builders for nicotine bentonite and lead arsenate have prompted the writers to prepare this note, in order that other workers may be able to make use of the information this season.

Deposit-building mixtures, usually referred to as inverted spray mixtures, of lead arsenate, mineral oil, and soap have been developed by Marshall *et al.* (1934), Marshall (1936), and other investigators for use in codling moth control. With these mixtures the quantity of soap required is regulated by water hardness, which varies greatly. It is therefore difficult, if not impossible, for some growers to determine the correct proportions of the spray ingredients. The use of deposit-building formulas is especially complex in the Middle West, where a weak bordeaux mixture is generally used with lead arsenate as a fungicide and safener.

The term "inverted" is applied herein to a mixture in which the particles of solid, originally suspended in the aqueous phase of an oil-in-water emulsion, become wet by the oil. This change generally results in the formation of sticky, oily curds of variable size having strong adhesive properties when sprayed onto fruit surfaces.

Late in 1941, during the course of experiments in which the larvicidal efficiencies of certain mixtures of soybean oil and nicotine bentonite were being compared at the Vincennes, Ind., laboratory of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, it was found that sprayable inverted mixtures of crude soybean oil and nicotine bentonite could be made without the addition of a soap. This led to the discovery that the foots, or settlings, which usually are precipitated in soybean oil by moisture and low temperatures, were largely responsible for inversion. Crude raw soybean oil made by the expeller process normally contains about 2.5 to 3 per cent of this material, which is available on the market as crude phosphatides, said to contain 40 to 60 per cent of lecithin and cephalin. The diluent consists mostly of soybean oil, with some moisture and other ingredients. Lecithin and cephalin are insoluble in acetone. The acetone-insoluble fraction constituted approximately 60 per cent of the crude phosphatides used in the spray mixtures discussed herein.

The materials were applied to 2-inch Rome apples with a converted orchard-type sprayer at 300-pound pressure. The sprayer had two three-sixty-fourths-inch-aperture nozzles, which were 6 inches apart and placed 30 inches from the fruit. Two gallons of spray passed through the nozzles per minute. The apples were placed on a device that caused them to rotate twice while passing through the spray cone. An exposure of 4 seconds resulted in a very slight run-off with most mixtures. Many of the apples were given three 4-second exposures, at intervals of 26 seconds.

Inversion in the tank sometimes produced mixtures that could not be sprayed because of adherence to the sides of the tank or because the curds were either too light or too heavy to make a uniform suspension. This occurred less frequently among the nicotine bentonite combinations. Some formulas gave heavier deposits when the concentrated mixtures were inverted by strong agitation before being diluted to spray strength.

The nicotine bentonite was prepared dry in a dust mixer, in the proportion of 1 quart of nicotine sulfate (40 per cent nicotine) to 10 pounds of powdered Wyoming bentonite. The lead arsenate was used with weak bordeaux mixture and kerosene. The phosphatides when used were first dissolved in the kerosene. The results are given in table 1.

In other tests the quantity of the soybean phosphatides required to bring about inversion did not appear to be affected by water hardness. In addition to agitation, however, the total surface area of the

Table 1.—Effectiveness of crude phosphatides as deposit builders with nicotine bentonite and with lead arsenate.

Spray Ingredients, Quantity per 100 Gallons	Pounds of Acetone-Insoluble Material per 100 Gallons	Spray Deposits, Mg. per Sq. Cm.	
		Exposure 4 Seconds	Exposure 12 Seconds
		Nicotine	
Dry-mix nicotine bentonite 5 lb., mineral oil 2 qt.	—	3.8	3.5
Dry-mix nicotine bentonite 5 lb., crude soybean oil 2 qt.	0.11	8.9	17.0
		Arsenic trioxide	
Lead arsenate 3 lb., copper sulfate 0.5 lb., hydrated lime 1 lb., kerosene 2 qt.	—	10.3	15.6
Lead arsenate 3 lb., copper sulfate 0.5 lb., hydrated lime 1 lb., kerosene 2 qt., crude phosphatides	.25	17.8	38.1
	.50	29.5	75.3
	1.00	29.0	79.0

solids in a spray mixture was found to be very important. Thus a micronized factory-processed nicotine bentonite required more phosphatides than the regular grade of identical chemical composition. Lead arsenate with bordeaux mixture required still larger amounts. The flocculated tank-mix nicotine bentonite prepared as described by Steiner & Sazama (1938) could not be made to invert with less than 1.5 pounds of the acetone-insoluble material per 100 gallons.

Differences in the swelling and nicotine-combining properties of bentonite from different sources have been reported by Fahey (1941). The swelling property of Wyoming bentonite in the dry-mix nicotine bentonite was destroyed by mixing the nicotine sulfate with the bentonite before the mixture was dispersed in water, and this mixture could be made to build deposits with the addition of relatively small amounts of the phosphatides. By utilizing a Mississippi bentonite of low swelling value, but having nicotine-combining properties equivalent to Wyoming bentonite, a promising tank-mix formula was devised. Three pounds of this bentonite, 0.83 pint of nicotine sulfate, 2 quarts of crude soybean oil containing 0.19 pound of the acetone-insoluble material, and 0.25 pound of zinc sulfate in 100 gallons of spray mixture deposited 10.6 and 22.6 mg. of nicotine per square centimeter after 4 and 12 seconds of spraying, respectively.

In other tests not reported in detail, the addition of zinc sulfate (monohydrated) to dry-mix nicotine bentonite permitted a reduction either in amount of agitation or of phosphatide required. Although not essential in soybean oil-nicotine bentonite mixtures, zinc sulfate or other inorganic salts have been found necessary for best results when the phosphatides are used with mineral oil.

The tests with lead arsenate were also favorable. Other inorganic salts are not necessary to form deposit-building sprays with lead arsenate, but it is believed that bordeaux mixture, zinc sulfate, or zinc sulfate and lime should be included to aid in preventing arsenical injury. Parallel analyses for copper deposits showed the same tendencies, but the proportion of build-up was not so great.

Although the phosphatides can be separated from soybean oil or the marketed crude material and used in this form, best results have been obtained by dissolving the crude product directly in the oil. There is some evidence that the free fatty acids in the crude phosphatides are also important.

The chemical aspects of the problem require further study. It also remains to be determined whether much variation in performance will occur when crude phosphatides from different sources are used, and if satisfactory results can be obtained when the materials are applied to fruit from greater distances. The effects on the tree, the type of deposits, the resistance to weathering, and, above all, the effects on various stages of the insect remain to be investigated.

To control the codling moth in most regions, spraying past the point where run-off begins cannot be avoided in some parts of the tree if the more distant apples are to be thoroughly covered. Non-deposit-building mixtures must necessarily be wasteful.

The results indicate that an effective deposit builder for high cost lead arsenate substitutes may be available, with a consequent saving in cost and materials even where no "overspraying" is done. An important advantage of deposit-building sprays is that they make it possible for the spray men to obtain equal deposits in the top and lower parts of the tree by applying a greater volume of material to the tops.—9-23-42.

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Codling Moth Oviposition and Fate of Eggs

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Information concerning codling moth oviposition under natural conditions and what becomes of the eggs is relatively meager. Therefore, studies on oviposition were conducted in a 60-acre orchard near Vincennes, Ind., in 1938. The orchard was approximately 37 years old and, except for 36 trees, had not been sprayed.

EXPERIMENTAL SET-UP AND METHODS.—A total of 520 marked bearing fruit spurs on 11 Ben Davis and 2 Rome trees were examined twice weekly during the season. Different spray schedules were applied to five of the Ben Davis trees examined. These five trees, along with four of the unsprayed trees, were scattered through a 15-acre bait-trap area. The other four unsprayed trees were in a similar but unbaited block. During May and June the eggs found on all trees and during the remainder of the season those on nine of the trees were traced until their fate was determined. The spurs were identified by small numbered tags. The location and condition of each egg were recorded on a special form. If the egg was on a leaf, the upper or lower surface was indicated and the leaf was marked with a bit of red yarn around the petiole. At the next examination reference was made to the record form, and changes in the status of the egg and the presence of any new eggs were recorded. As soon as an egg hatched, died, or became parasitized, it was removed.

Because of the variety of conditions to which the trees were subjected and the limited number on which it was possible to make examinations, too much significance should not be attached to differences shown between baited and unbaited trees, or between sprayed and unsprayed trees. The data obtained, however, throw additional light on the behavior of the moth and on the relative importance of parasites, predators, natural mortality, and scaling off of eggs under certain orchard conditions, and indicate a definite need for extensive investigation of each of the factors discussed under a variety of environmental conditions.

DISTRIBUTION OF EGGS.—Of a total of 3581 eggs observed on bearing spurs during the season only 6 per cent were deposited on the fruit. The proportion on fruit increased from 2.4 per cent in May to 11.3 per cent in September. These data do not take into account oviposition on non-bearing spurs or elsewhere on the tree. On each tree examined, 20 of the marked spurs were located in the upper third of the tree and 20 on lower branches within reach from the ground. Of the 3581 eggs, 57.3 per cent were deposited in the tops of the trees and 42.7 per cent near the ground. The distribution, on unsprayed trees only, is shown by months in table 1.

Table 1.—Comparative egg deposition in the upper and lower parts of four unbaited and four baited trees that were not sprayed.

	UNBAITED TREES		BAITED TREES	
MONTH	Total Number of Eggs	Per Cent on Upper Part of Trees	Total Number of Eggs	Per Cent on Upper Part of Trees
May	120	62.5	52	28.8
June	428	58.2	222	59.5
July	671	62.9	388	50.0
Aug.	385	60.5	230	50.9
Sept.	40	60.0	49	32.7
Total	1644	61.0	941	50.4

[1] The writers were assisted in this work by B. E. Hodgson, C. C. Alexander and W. E. Kurtz.

In the unbaited area approximately 60 per cent of the total eggs were deposited in the upper part of the trees, with little variation in the ratio during the season. In the baited area the rate of oviposition for the season in the upper section was approximately equal to that in the lower section, but the ratio was variable. These data suggest that bait traps reduce oviposition in the top of the trees more than at lower levels and that in the absence of of traps the most eggs per apple are deposited in the top of the trees. Short periods of windy or rainy weather appeared to force oviposition at a lower level in all areas. In June, when egg distribution in the baited trees was most similar to that in the unbaited trees, the traps captured fewer moths in relation to moth emergence, moth abundance, and number of eggs than in any other month of the season, owing apparently to the great numbers of armyworm adults appearing in the traps at that time, which reduced their effectiveness in trapping codling moths.

The baited and unbaited trees were not properly distributed to test the effect of the traps on the number of eggs deposited; hence the actual reduction effected by the traps may have been more or less than the 43 per cent observed.

INTERSPUR MOVEMENT OF NEWLY HATCHED LARVAE.—On many spurs more injuries than hatched eggs were found. On 160 spurs on the four unsprayed trees where the eggs under observation were allowed to remain until their fate was determined, approximately 280 eggs hatched but a total of 411 worm and sting injuries were found. Undoubtedly a few eggs were overlooked but, with examinations being made at 3- or 4-day intervals and by different observers on successive dates, most spurs would be subject to 2 and sometimes 3 examinations by different persons between the time of oviposition and hatch. It is believed that the larvae traveled from other bearing and possibly from nonbearing spurs and that some larvae made more than one injury. That extensive travel by newly hatched larvae is a natural occurrence has been reported by Steiner (1939).

FATE OF EGGS ON UNSPRAYED TREES.—Observations were made to determine the fate of all eggs deposited on 40 fruit spurs on each of the unsprayed trees. During May and June an average of approximately two eggs were deposited per spur. Of these, an average of 37 per cent hatched, 32 per cent were parasitized by *Trichogramma minutum*, 19 per cent were destroyed by predators, chiefly *Chrysopa* spp., 5 per cent died or were infertile, and 7 per cent disappeared from the tops of the trees and from the upper surface of the leaves, this loss being caused largely by their scaling off.

From July to September, inclusive, an average of approximately four eggs were

Table 2.—Fate of codling moth eggs deposited on trees receiving different spray treatments.

Treatment	Number of Trees Examined	Total Number of Eggs	Percentage of Eggs				
			Hatched	Parasitized[1]	Destroyed by Predators	Dead[1]	Lost
Unsprayed and baited	2	413	32	33	23	6	6
Unsprayed and unbaited	2	567	25	46	20	3	6
Lead arsenate, weak bordeaux with 0.5% mineral oil in 2 of 9 cover sprays	1	129	19	27(10)	30	18(26)	5
Factory-processed nicotine bentonite with 0.5% mineral oil in 8 cover sprays	1	189	33	10(3)	33	14(22)	10
Tank-mix nicotine bentonite with 0.25% soybean oil in 8 cover sprays	1	65	25	41	25	5	5
Tank-mix nicotine bentonite with 0.5% soybean oil in 8 cover sprays	1	40	12	38(19)	15	25(38)	10
Phenothiazine (regular), 4 lb. to 100 gal. in 8 cover sprays	1	573	20	52	11	8	9

[1] Numbers in parentheses indicate percentages for May and June only.

deposited per spur. Of these, an average of 25 per cent hatched, 43 per cent were parasitized by *Trichogramma minutum*, 23 per cent were destroyed by predators, 4 per cent died or were infertile, and 5 per cent disappeared.

FATE OF EGGS ON SPRAYED TREES.—The fate of the eggs deposited throughout the season on trees receiving different spray treatments as compared with that of eggs deposited on unsprayed trees in baited and unbaited areas is given in table 2. The parasitization and mortality of eggs during May and June is also indicated in the case of certain treatments. Because of the small number of trees represented, too much weight should not be given to differences between treatments. Certain differences, however, are large enough to justify further investigations.

Where mineral oil was used with lead arsenate and with nicotine bentonite the percentage of parasitized eggs was the lowest. Parasitization was considerably higher in the unbaited than in the baited area, an indication that the baits may have adversely affected the parasite population. Whereas parasitization was greatest on the plot sprayed with phenothiazine—an insecticide which kills largely by contact, as indicated by other investigations—destruction by predators was least there. Destruction by predators was greatest on the trees where parasitization was low. As was expected, egg mortality was highest where mineral or soybean oil at 0.5 per cent was used. The loss of eggs was greatest where 0.5 per cent oils were used with nicotine bentonite and in the phenothiazine treatment.

A separate experiment indicated that heavy spray deposits interfered with the retention of eggs, particularly on foliage most exposed to rain and wind.

EFFECT OF SPRAYS ON OVIPOSITION AND ON EGG PARASITIZATION.—To determine the relative amounts of oviposition and of parasitization by *Trichogramma minutum* on sprayed and unsprayed trees, 50 bearing spurs were examined, 25 before and 25 after the seventh cover spray, on 6 trees for each treatment. The plots were arranged in a restricted randomization consisting of single-tree plots replicated 6 times in different areas in the orchard. Most of the trees were immediately adjacent to one or more unsprayed trees. The results of this examination are given in table 3.

Table 3.—Effect of spray treatments on oviposition, egg parasitization, and moth captures in bait traps.

Treatment	Number of Eggs per 300 Fruit Spurs	Per Cent of Eggs Parasitized	Average Number of Moths per Trap	
			Before June 30	After June 30
Unsprayed	979	54.4	35	104
Lead arsenate	99	25.3	30	112
Tank-mix nicotine bentonite and ½% soybean oil	116	46.6	62	128
Phenothiazine	646	62.4	60	95

The apparent reduction in oviposition of approximately 90 per cent in the plot treated with lead arsenate and 88 per cent in the plot treated with nicotine bentonite in comparison with the unsprayed plot suggests that these treatments were objectionable to ovipositing moths. Since the examination was made as second-brood deposition was approaching its peak, it is possible that some of the difference was due to the reduction in moth population effected by the spray treatments during the first brood, and that in the nicotine plot some moths were killed by the seventh cover spray. The reduction in first-brood worm entrances amounted to 81 per cent for phenothiazine and approximately 90 per cent for lead arsenate and nicotine.

Intertree movement of moths, however, is extensive (Steiner 1940), and the fact that egg deposition during spring-brood moth flight was also much less in the single-tree plots treated with lead arsenate and nicotine indicates that it was reduced as a result of a lowered attraction of the tree to the adult moth, a definite repellent action keeping or driving moths out of the tree, or a reduction of the urge to oviposit after they entered the tree.

That the last factor may have been largely responsible is indicated by bait-trap records shown in table 3. These records were taken from three replications of the spray treatments and of the unsprayed check, all of which were located in one corner of the bait-trap area. It is evident that the moth catches were normal in sprayed trees both during the spring-brood period and after July 1. The evidence indicates that the treatments did not keep the moths out of the trees but

rather that they reduced oviposition by covering surfaces that might have stimulated the moths to deposit eggs. It must be recognized, however, that the traps in sprayed trees might have been more efficient than those in unsprayed trees if the attraction to fruit and foliage was lowered; hence equal moth catches do not necessarily mean that the trees supported equal populations.

Trees sprayed heavily with nicotine bentonite or lead arsenate and bordeaux are whitened to such an extent that, except under very favorable light conditions, not all eggs can be seen. In 1939 careful studies were made to determine what proportion of the eggs are likely to be missed in successive examinations. Moths were caged over scattered twigs for a 1-day period. The twigs were then marked and examined for eggs at 2-day intervals until 6 to 8 examinations had been made. The eggs found were marked with a circle in India ink. Of 1887 eggs deposited on foliage coated heavily with tank-mix nicotine bentonite or lead arsenate sprays, 14 per cent were missed at the first examination and 3.2 per cent were not found until 3 or more examinations had been made. On foliage covered with inconspicuous deposits of other materials, less than 3 per cent of 825 eggs were overlooked at the first examination.

The proportion of eggs parasitized by *Trichogramma minutum* was significantly less in the plot treated with lead arsenate than in the unsprayed plot or the plots receiving the other treatments. In general, egg parasitization following the treatments included in this test was similar to that following the respective treatments in the single-tree all-season tests (Table 2).

SUMMARY.—During the season of 1938, 520 marked bearing fruit spurs on apple trees were examined twice weekly in order to obtain information on the egg-laying habits of the codling moth and to determine the fate of eggs deposited under natural conditions. Of 3581 eggs observed, only 6 per cent were deposited on the fruit. On the unbaited trees about 60 per cent of the eggs were deposited in the upper branches but in the presence of bait traps the rate of oviposition in treetops was approximately the same as that in the lower branches.

On unsprayed trees parasitization by *Trichogramma minutum* averaged 32 per cent in May and June and 43 per cent from July to September, inclusive. Only 37 per cent of the first-brood eggs and 25 per cent of those deposited from July to September hatched. Predators, believed to consist largely of *Chrysopa* spp., accounted for 19 per cent of the first-brood eggs and 23 per cent of the second-brood eggs. Approximately 10 per cent of the eggs died or were lost.

Bait traps appeared to reduce parasitization slightly but there was no evidence to indicate that they had any effect on predators.

Mineral oil with lead arsenate or with nicotine bentonite appeared to reduce parasitization, but this reduction was offset by increased destruction of codling moth eggs by predators. Parasitization was greatest and the destruction by predators the least in the plot sprayed with phenothiazine. The mortality of eggs was greatest where 0.5 per cent soybean oil or mineral oil was used with lead arsenate or with nicotine bentonite. The disappearance of eggs was greatest where the deposits from spray treatments were heaviest.

Lead arsenate and tank-mix nicotine bentonite with soybean oil appeared objectionable to ovipositing females. The evidence indicates that the reduction was effected not by keeping or driving the moths from the tree, but instead by making leaf and fruit surfaces unattractive to gravid females.

Although these observations and data probably are not indicative of what might be considered normal, they do emphasize the importance that predators, parasites, and control treatments may assume under certain conditions with respect to the abundance and fate of codling moth eggs. —10-3-42.

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The Relative Effectiveness of Calcium Arsenates Composed of Large and of Small Particles[1]

J. C. GAINES and H. A. DEAN,[2] *Texas Agricultural Experiment Station, College Station*

In previous investigations (Gaines 1940, 1941) it was shown that a special calcium arsenate containing large particles and a high percentage of water-soluble arsenic pentoxide gave better control of rapid plant bugs, *Adelphocoris rapidus* (Say), than did the commercial calcium arsenate. The special calcium arsenate and commercial calcium arsenate were equally effective against the boll weevil, *Anthonomus grandis* Boh. The special calcium arsenate used in the present experiments contained less water-soluble arsenic pentoxide, or about the same percentage as commercial calcium arsenate, but the particles were larger. This material and a commercial calcium arsenate were tested in the laboratory against the southern armyworm, *Prodenia eridania* (Cram.), and in field plots against the boll weevil and the bollworm, *Heliothis armigera* (Hbn.), at College Station, Tex., and against the boll weevil at Tallulah, La. In the plot tests at both locations a mixture of the special calcium arsenate, sulfur, and rotenone was also used, and the effects of these insecticides on aphids, *Aphis gossypii* Glov., and plant bugs were also observed.

LABORATORY TESTS.—For comparison of the two calcium arsenates, known doses of each were fed to about 100 fifth instars of *Prodenia eridania* that had been reared in the laboratory. Dosages in mg. per gm. of body weight (multiplied by 1000) were changed to logarithms and plotted against probits (Bliss 1938), a transformation suitable to percentages of mortality. The lines of best fit are shown in Fig. 1. The median lethal dose for commercial calcium arsenate was 0.264 mg. per gm. and for special calcium arsenate 0.302 mg. per gm. The coarser material was not so effective as the finer material.

FIELD TESTS.—The plots at College Station had a dusting area of one-tenth acre and a picking area, after the buffers were eliminated, of one-twentieth acre. Those at Tallulah had a dusting area of one-fourth acre and a picking area of one-thirtieth acre. At both locations they were arranged in randomized blocks, and each treatment was replicated four times.

The treatments consisted of a check; commercial calcium arsenate containing 41.2 per cent of total arsenic pentoxide and 8.1 per cent of water-soluble arsenic pentoxide at College Station and 41.8 per cent of total arsenic pentoxide and 9.1 of water-soluble arsenic pentoxide at Tallulah, with a mean surface particle diameter (by air permeation) of 1.1 microns in each case; special calcium arsenate containing 39.6 per cent of total arsenic pentoxide and 8.7 per cent of water-soluble arsenic pentoxide, with a mean surface diameter of 2.7 microns; and a mixture of special calcium arsenate, sulfur and cube (75-15-10) containing 29.1 per cent of total arsenic pentoxide, 3.0 per cent of water-soluble arsenic pentoxide, and 0.34 per cent of rotenone.

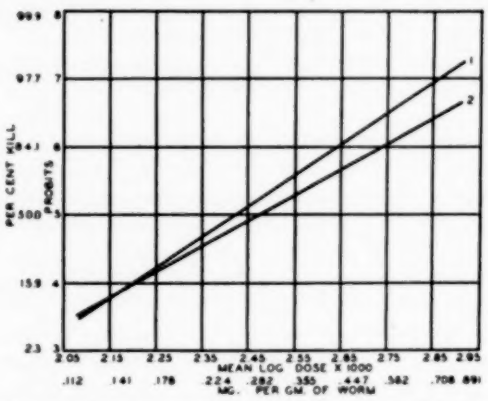

FIG. 1.—Dosage-mortality curves for the toxicity of (1) commercial calcium arsenate and (2) special calcium arsenate to *Propenia eridania*.

Eleven effective early-morning applications were made from June 24 to August 21 at the rate of 8 to 9 pounds per acre at College Station and seven from June 28 to August 9 at the rate of 6 pounds per acre at Tallulah.

[1] Technical contribution 737 of the Texas Agricultural Experiment Station, in cooperation with the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

[2] Niagara Sprayer and Chemical Company Fellowship.

E. W. Jackson and D. C. Thurman assisted in taking the field notes at College Station. R. C. Gaines, M. T. Young, G. L. Garrison, T. F. Henderson, W. A. Lee, and R. R. Coffin conducted the experiment at Tallulah, La. The chemical analyses of insecticides were made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Table 1.—Cotton insect infestation and yield of seed cotton following the various treatments.

Location and Treatment	Boll Weevil Infestations		Bollworm Infestations		Number of Rapid Plant Bugs[1] per 200 Squares	Number of Aphids per Square Inch	Pounds of Seed Cotton	
	Per Cent Squares Punctured	Equivalent Angles	Per Cent Forms Injured	Equivalent Angles			Per Plat (One-Tenth Acre)	Per Acre
College Station:								
Check	18.5	25.2	18.6	25.6	4.0	1.96	69.85	698
Commercial calcium arsenate	6.8	15.0	8.9	17.2	2.5	10.63	132.42	1,324
Special calcium arsenate	7.4	15.5	11.6	19.9	2.0	12.13	116.78	1,168
Special calcium-arsenate-sulfur rotenone	10.2	18.3	12.6	20.6	3.2	.93	122.50	1,225
Minimum significant difference		4.2		3.1	1.4	1.2	14.6	
Tallulah:								
Check	62.6	52.3			1.0	16.07	156.30	1,563
Commercial calcium arsenate	32.0	34.4			.5	33.96	169.00	1,690
Special calcium arsenate	31.4	33.9			.6	29.25	172.81	1,728
Special calcium arsenate-sulfur-rotenone	41.5	39.9			.4	16.22	198.92	1,989
Minimum significant difference		7.3				8.2	18.4	
Both locations:								
Check	40.6	38.8			2.5	9.02	113.08	1,131
Commercial calcium arsenate	19.4	24.7			1.5	22.30	150.71	1,507
Special calcium arsenate	19.4	24.7			1.3	20.69	144.80	1,448
Special calcium arsenate-sulfur rotenone	25.8	29.1			1.8	8.58	160.71	1,607
Minimum significant difference		3.9				3.9		

[1] Tarnished plant bugs included in record at Tallulah.

Boll weevil infestation records were made at approximately 5-day intervals at College Station and 7-day intervals at Tallulah. Two hundred squares were examined on the middle rows of each plot on each date.

Bollworm infestation records were made at approximately 5-day intervals. Two hundred squares and 200 bolls were examined on the middle rows of each plot.

The aphid population records were made at weekly intervals during the dusting period. The aphids were counted on a square inch of leaf area in the center of the fourth leaf from the top on 10 to 100 consecutive plants at 2 to 3 points in each plot.

The number of rapid plant bugs found on the squares examined for boll weevil punctures was recorded.

Tests of significance were made by the method of analysis of variance. Instead of percentages of boll weevil and bollworm infestations, corresponding angles (Bliss (1938) were used throughout the analysis. Table 1 contains averages of the treatment replicates for the different criteria and table 2 contains summaries of the analyses for each set of data. In every case where the *F* test indicated that the treatment means differed significantly among themselves, the differences required to indicate the minimum value that can be considered as significant are given (Table 2).

It will be noted that the special calcium arsenate was equally effective against weevils as commercial calcium arsenate at both locations. The mixture of special calcium arsenate, sulfur, and rotenone was not so effective as the arsenicals alone, owing in part to the slightly smaller poundage of arsenate in the mixture. At College Station commercial calcium arsenate was more effective against bollworms than either the special calcium arsenate or the

special calcium arsenate mixture. The plant bug population was low, and only small differences occurred between treatments. The special calcium arsenate mixture significantly controlled the aphid infestation at both locations. The commercial calcium arsenate gave the highest yield at College Station, because of better water-soluble arsenic pentoxide was approximately the same.

SUMMARY.—A special calcium arsenate containing large particles, a special calcium arsenate, sulfur, rotenone mixture, and commercial calcium arsenate were tested against the boll weevil, bollworm, and aphids at College Station, Texas, and against the boll weevil and aphids at Tallulah, La. Records were also kept on rapid plant bug populations at both locations, but the populations were low and only small differences occurred between treatments. The special calcium arsenate and commercial calcium arsenate were equally effective against weevils at both locations, but the coarse material (special calcium arsenate) did not give as good control of bollworms at College Station as the commercial calcium arsenate. Both materials contained approximately the same percentage water-soluble arsenic pentoxide. The special calcium arsenate, sulfur, rotenone mixture significantly controlled the aphids and increased the yield at Tallulah while the aphids did not injure the cotton sufficiently at College Station for the mixture to increase the yields.—9-11-42.

Table 2.—Analyses of variance of the data shown in table 1.

Locality and Source of Variation	DF	Mean Square Pertaining to— Boll Weevil Investation Angles	Bollworm Infestation Angles	Population Aphid	Rapid Plant Bug Population[1]	Yield
College Station:						
Blocks	3	34.18	6.66	1.52	2.61	949.50
Treatment	3	87.56[2]	48.35[2]	133.95[3]	3.05[2]	3088.61[3]
Error	9	7.05	3.75	.76	.59	87.40
Total	15	28.58	13.25	27.55	1.49	860.06
Tallulah:						
Blocks	3	53.48		33.78	.03	88.05
Treatment	3	293.55[3]		333.37[3]	.23	1280.80[3]
Error	9	21.03		26.50	.08	132.72
Total	15	82.03		89.30	.10	353.40
Combined experiments:						
Blocks	6	43.83		17.65		518.77
Treatment	3	350.44[3]		433.70[3]		3386.74[3]
Location	1	3727.51		2439.17		32364.38
Treatment × Location	3	30.66		33.61		982.67[3]
Error	18	14.04		13.63		110.06
Total	31	173.76		135.24		1639.88

[1] Tarnished plant bugs included in record at Tallulah.
[2] Significant.
[3] Highly significant.

bollworm control, whereas the special calcium arsenate mixture gave the highest yield at Tallulah, because of better aphid control. At College Station the aphid population was not high enough to cause much loss on these plots.

In the combined analysis of yields it will be noted that the locality-treatment interaction was significant, an indication that the treatments did not have the same reaction at both locations. At Tallulah increased aphid control, by the special calcium arsenate mixture caused an increase in yield, whereas at College Station aphid control did not increase the yield significantly.

Laboratory tests against the southern armyworm and the bollworm control obtained in field tests indicated that the coarser material was not so effective as the finer material when the percentage of

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Comparative Tests of Certain Insecticides and Variations in Schedules for Cotton Insect Control[1]

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In a recent report (Gaines 1941) it was shown that lead arsenate and cryolite-sulfur (85-15) gave better control of the bollworm, *Heliothis armigera* (Hbn.), than commercial calcium arsenate. The arsenicals were more effective against the boll weevil, *Anthonomus grandis* (Boh.), than is cryolite.

In additional tests at College Station, Texas, in 1941 lead arsenate and cryolite were used in schedules with commercial calcium arsenate for weevil and bollworm control. Two consecutive applications of lead arsenate and of cryolite were made when bollworm injury was at its peak. The comparative effectiveness of calcium-zinc arsenate and calcium arsenate-rotenone against aphids, as well as weevils and bollworms, was also tested.

FIELD PLOTS AND TREATMENTS.—In experiment 1 the plots were arranged in randomized blocks and each treatment was replicated three times. The dusting area of each plot was one-tenth acre and the picking area, after the buffers were eliminated, was one-twentieth acre. The treatments consisted of a check, calcium arsenate containing 41.8 per cent of total arsenic pentoxide and 6.4 per cent of water-soluble arsenic pentoxide, calcium-zinc arsenate containing 36.6 per cent of total arsenic pentoxide and 0.3 per cent of water-soluble arsenic pentoxide, and calcium arsenate-rotenone containing 36.6 per cent total arsenic pentoxide, 10.8 per cent water-soluble arsenic pentoxide, and 0.27 per cent rotenone. Nine effective early-morning applications were made from July 1 to August 21 at the rate of 8 pounds per acre.

In experiment 2 the plots were also arranged in randomized blocks, and each treatment was replicated twice. The dusting area of each plot was one-eighth acre and the picking area one-eighteenth acre. This experiment was started after two applications of calcium arsenate had been made to the entire cut of cotton for boll weevil control. The treatments consisted of a check, calcium arsenate with a chemical analysis similar to that used in experiment 1, alternate applications of calcium arsenate and natural cryolite-sulfur (85–15) containing 75.7 per cent of sodium fluoaluminate, and alternate applications of lead arsenate-clay 90–10 containing 29.2 per cent of total arsenic pentoxide and 0.12 per cent of water-soluble arsenic pentoxide. Six early-morning applications were made from July 23 to August 16 at the rate of about 9 pounds per acre.

RECORDS.—Boll weevil infestation records were made at approximately 5-day intervals. Two hundred squares on the middle rows of each plot were examined and the percentage punctured recorded. Bollworm infestation records were also made at approximately 5-day intervals. Two hundred squares and 200 bolls on the middle rows of each plot were examined and the injured forms recorded. Aphid population records were made at weekly intervals during the dusting period. Counts were made of the aphids present on a square inch of leaf area in the center of the fourth leaf from the top on 50 con-

[1] Technical contribution 736 of the Texas Agricultural Experiment Station, in cooperation with the Bureau of Entomology nd Plant Quarantine, U. S. Department of Agriculture.

[2] H. A. Dean, E. W. Jackson, and D. C. Thurman assisted in taking the field notes. Chemical analyses of the insecticides were made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Table 1.—Cotton insect infestation and yield of seed cotton following the different treatments.

Treatments	Boll Weevil Infestation		Bollworm Infestation		Number of Rapid Plant Bugs per 200 Squares	Number of Aphids per Square Inch	Pounds of Seed Cotton	
	Per Cent of Squares Punctured	Equivalent Angles	Per Cent of Forms Injured	Equivalent Angles			Per Plot	Per Acre
			Experiment 1					
Check	7.1	15.4	25.3	30.1	8.4	5.0	31.95	639
Calcium arsenate	2.4	8.8	10.7	19.1	3.0	19.1	62.99	1,260
Calcium-zinc arsenate	2.9	9.7	8.7	17.1	7.2	13.9	70.65	1,413
Calcium arsenate-rotenone	2.8	9.6	10.8	19.1	2.9	4.1	69.17	1,383
Minimum significant difference		2.9		4.5	2.8	2.3	7.73	
			Experiment 2					
Check	35.9	36.81	9.4	17.69	7.2		51.65	930
Calcium arsenate	12.0	20.31	5.0	12.94	1.2		76.38	1,375
Calcium arsenate and cryolite[1]	16.7	24.10	7.0	15.30	4.6		69.00	1,242
Calcium arsenate and cryolite[2]	21.9	27.72	5.2	13.24	6.2		74.00	1,332
Calcium arsenate and lead arsenate[1]	9.0	17.38	3.8	11.15	1.9		81.22	1,462
Calcium arsenate and lead arsenate[2]	14.4	22.30	3.2	10.55	3.8		78.04	1,405
Minimum significant difference		5.58			3.6			

[1] Alternate applications using two applications of cryolite or lead arsenate, as indicated during the period bollworm injury was highest.
[2] Following applications of calcium arsenate two consecutive applications of cryolite or lead arsenate, as indicated, made at 5-day intervals at the peak of bollworm injury.

secutive plants at each end of each plot. The number of rapid plant bugs found on the squares examined for boll weevil punctures was recorded.

RESULTS.—Seasonal averages made during the dusting period for all replicates of the different criteria are shown in table 1 together with the average plot and acre-age yields. The results of the statistical analyses are summarized in table 2. The percentages for boll weevil and bollworm infestations were transformed into angles before analysis of variance was carried through. In seven of the nine cases the ratio of treatment variance to error variance (F-test) indicated that there were sig-

Table 2.—Analyses of variance of data shown in table 1.

Experiments and Source of Variation	DF	Mean Square Pertaining to—				
		Boll Weevil Infestation Angles	Bollworm Infestation Angles	Aphids Population	Rapid Plant Bug Population	Yield
			Experiment 1			
Blocks	2	0.28	8.88	4.46	10.58	54.58
Treatments	3	27.91[2]	104.52[2]	157.86[2]	24.04[2]	986.29[2]
Error	6	2.12	5.01	1.30	1.92	14.97
Total	11	8.82	32.85	44.57	9.53	287.08
			Experiment 2			
Blocks	1	17.59	.03		1.02	16.26
Treatments	5	93.92[2]	14.16		11.06[1]	227.01
Error	5	4.73	4.01		1.90	51.74
Total	11	46.44	8.26		5.98	128.18

[1] Significant.
[2] Highly significant.

nificant differences between treatment means. To facilitate comparison of the means the least differences that can be considered significant have been added to the various groups of table 1.

In experiment 1 calcium arsenate, calcium-zinc arsenate and calcium arsenate-rotenone were equally effective against weevils, but the calcium arsenate-zinc arsenate was not so effective against rapid plant bugs as either calcium arsenate or calcium arsenate-rotenone. Calcium arsenate-rotenone was significantly better against aphids than either of the other materials. The yields indicated that calcium-zinc arsenate and calcium arsenate-rotenone were equally effective and better than calcium arsenate alone, but the differences were not significant. The higher yield following treatment with calcium arsenate-rotenone was due to aphid control and the higher yield following treatment with calcium-zinc arsenate was due to slightly better bollworm control and a retarding of the aphid increases for nearly 2 weeks. This last-named product was finely ground and covered the plants well, possibly making it a little more effective against bollworms, although there may have been a beneficial effect from the presence of a minor element.

In experiment 2 two applications of lead arsenate and four of calcium arsenate at 5-day intervals, when bollworm injury was at its peak gave better control of both weevils and bollworms than either calcium arsenate alone or alternate applications of cryolite and calcium arsenate. When two consecutive applications of either lead arsenate or cryolite were made the weevil infestation increased and caused some loss.

SUMMARY.—In experiment 1, calcium-zinc arsenate gave a little better control of bollworms than either calcium arsenate alone or calcium arsenate-rotenone mixture, but the difference was not significant Calcium arsenate-rotenone prevented aphid increases better than calcium-zinc arsenate. The yields indicated that calcium arsenate-rotenone and calcium-zinc arsenate were equally effective and better than calcium arsenate alone. The higher yield recorded on the calcium arsenate-rotenone and calcium-zinc arsenate treated plats was due to aphid control in the first case and slightly better bollworm control as well as retarding aphid increases at least 2 weeks in the latter.

In experiment 2 alternate applications of calcium arsenate and lead arsenate, using 2 applications of lead arsenate during the peak of bollworm injury, gave good control of both weevils and bollworms. Losses in yields occurred when cryolite was used in this manner, because of the increased weevil injury. Two consecutive applications of either lead arsenate or cryolite at the peak of bollworm injury instead of calcium arsenate did not prove to be effective against the weevils thus causing a loss in yield.—9-11-42.

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DR. CAMPBELL RETURNS TO COLUMBUS

Dr. F. L. Campbell, who has spent the past few months in Washington on War Emergency work has been recalled to Ohio State University to assist in the administration of the Ohio State University research Foundation which has undertaken a considerable amount of research sponsored by the United States Government in connection with War Emergency Problems. Dr. Campbell may therefore be addressed once more at Columbus.

Relation Between Winter Temperatures, Boll Weevil Survival, Summer Rainfall, and Cotton Yields

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A study of the factors which influence boll weevil injury to a particular cotton crop should start with the conditions that existed during the preceding fall. First, consideration should be given to the supply of feeding and breeding material for the boll weevil, which is affected by weather conditions during August, September, and October, defoliation by the cotton leaf worm, *Alabama argillacea* (Hbn)., and the date of the first killing frost. The number and condition of boll weevils entering hibernation are greatly determined by the supply of feeding and breeding material prior to the general movement to hibernation quarters. The winter temperatures to which boll weevils are exposed are influenced to a great extent by the shelter in which the insects overwinter. Temperatures during the winter months have a great influence on survival and emergence during the following spring and early summer. Weather conditions during the spring also have a direct influence on the number of surviving boll weevils that live long enough to find cotton plants and reproduce. The effect of summer rainfall on the rate of boll weevil multiplication is most important.

Each of these factors constitutes a separate study. Discussions of some of them for the years 1915–34 have been published (Gaines 1935, Young 1935). The correlation studies the results of which are presented in this paper are based on yearly records from 1915 to 1941 of weather conditions, boll weevil survival in various shelters, and estimates of yield in experimental plots and per planted acre.

WINTER TEMPERATURES AND BOLL WEEVIL SURVIVAL.—Available records pertinent to this study from 1915 to 1941, inclusive, are presented in table 1. The number of live boll weevils found in Spanish moss during the spring, the number surviving in hibernation cages, and the number found in cotton fields during May and June were each significantly correlated with the number of days on which the temperature from September to March fell below 32° F. The number of days from September to March on which the temperature fell below 20° F. was not significantly correlated with the number of live boll weevils found in Spanish moss during the spring, but it was significantly correlated with the number surviving in hibernation cages and the number found in cotton fields during May and June. The minimum temperature for the winter was significantly correlated with the number of weevils surviving in hibernation cages and apparently affected to a certain extent the number surviving in Spanish moss and the number found in cotton fields in May and June.

Evidently Spanish moss does not afford so great protection for boll weevils during the winter as certain other known shelters. Many boll weevils may be killed in Spanish moss before temperatures as low as 20° F. are encountered, and temperatures below 20° F. are usually fatal to a large proportion of the boll weevils in this shelter. In the hibernation cages some of the shelters that were used afforded greater protection to overwintering weevils than Spanish moss. Most boll weevils found in the cotton fields during May and June apparently found shelters which afforded more protection than Spanish moss.

Although only records for 1936 to 1940 were available, the number of boll weevils found in ground trash from woods adjacent to cotton fields was more closely associated with the number found in cotton fields during May and June than either the number found in Spanish moss during the spring or the number surviving in hibernation cages.

OVERWINTERED BOLL WEEVILS AND COTTON YIELDS.—The number of boll weevils found in Spanish moss during the spring, the number surviving in hibernation cages, and the number found in the fields during May and June were each found to be nonsignificantly correlated with percentage increase in yield in experimental plots where the weevils had been controlled with calcium arsenate,

[1] The field work was performed by M. T. Young, G. L. Smith, G. L. Garrison, A. L. Scales, T. C. Barber, R. W. Howe, H. W. Lee, E. S. Tucker, H. C. Young, R. W. Moreland, F. F. Bondy, T. P. Cassidy, A. Thomae, A. J. Chapman, W. A. Stevenson, C. F. Rainwater, and a large number of temporary assistants.

yield per planted acre, and total yield in Madison Parish. This consistent lack of relationship indicates that other factors have a greater influence on the percentage increase in yield, yield per planted acre, and total yield in Madison Parish than the survival of overwintered weevils.

SUMMER RAINFALL AND COTTON YIELDS.—The total rainfall from June 21 to August 19 was significantly correlated with percentage increase in yield in experimental plots where boll weevils had been controlled with calcium arsenate, but it was not significantly correlated with either yield per planted acre or total yield in Madison Parish. The number of days on which there was 0.3 inch or more of rainfall from June 21 to August 19 was significantly correlated with percentage increase in yield in experimental plots and with total yield in Madison Parish but not with yield per planted acre in Madison Parish. These records indicate that total precipitation and the number of days on which there was 0.3 inch or more of rainfall from June 21 to August 19 have a much greater influence on percentage increase in yield in experimental plots than on yield per planted acre or total yield in Madison Parish.

A greater correlation occurred between the number of days on which there was 0.3 inch or more of rainfall from June 21 to August 19 and percentage increase in yield in experimental plots where weevils were controlled than between any other two variables.

The percentage increase in yield in experimental plots was significantly correlated with yield per planted acre and total yield in Madison Parish.

CONCLUSION.—Although the records were few, the number of boll weevils found in woods trash was associated with the number of boll weevils found in cotton fields during the following May and June. Since the correlations between winter temperatures and the number of weevils in cotton fields during May and June were significant, the inference would be that ground trash affords an important shelter for the weevils during the winter.

Table 1.—Summary of winter temperatures, boll weevil survival, summer rainfall, and cotton yields, Tallulah, La., 1915 to 1941.

Year	Weevils Entering Hibernation, Number		Number of Days from September to March When Temperature Fell Below—		Minimum Temperature for Winter, °F.	Weevils Surviving the Winter		
	Per Ton of Spanish Moss	Per Acre of Ground Trash	32° F.	20°F.		Per Ton of Spanish Moss, Number	Per Acre of Ground Trash, Number	In Hibernation Cages, Per Cent
1915–16			32	0	20	24.0		6.14
1916–17			45	5	16	8.0		.17
1917–18			60	14	1	1.7		.05
1918–19			45	4	9	4.0		.31
1919–20			39	2	18	9.5		.48
1920–21			35	1	16	22.0		1.38
1921–22			30	0	22.5	127.0		4.22
1922–23			26	0	20	19.0		1.59
1923–24			51	5	10.5	.5		.11
1924–25			49	4	15	.6		.01
1925–26	280		47	3	13	.0		.05
1926–27	242		30	4	16	4.0		—
1927–28	21		43	10	11	1.0		.02
1928–29	240		43	7	16	3.8		.78
1929–30	189		44	11	1.8	.2		.01
1930–31	49		37	0	20	33.0		5.34
1931–32	724		19	0	23	462.3		18.39
1932–33	881		28	3	12	1.3		.15
1933–34	365		29	0	20	40.8		7.51
1934–35	192		38	5	6	5.2		.11
1935–36	19		54	7	14	.0	141	.17
1936–37	141	2,118	31	0	22	23.0	50	11.87
1937–38	51	519	35	6	14	1.4	186	1.13
1938–39	4	1,284	33	3	15	6.7	226	1.16
1939–40	189	2,243	59	12	−8	.0	190	.01
1940–41	23	721	31	2	17	—	920	

Table 1—(Continued)

Year	Weevils per Acre on Cotton Plants During May and June, Number	Total Precipitation June 21 to August 19, Inches	Days with 0.30 Inch or More Precipitation from June 21 to August 19, Number	Increased Yield Over Checks in Plots Treated with Calcium Arsenate, Per Cent	Yield per Planted Acre in Madison Parish, Pounds[1]	Cotton Production in Madison Parish, Number of 500-lb. Bales[2]
1915–16	346					5,385
1916–17	4					11,217
1917–18	51					13,725
1918–19	73					4,766
1919–20	81	6.92	8	32.8		5,716
1920–21	129	9.32	9	44.6		7,406
1921–22	133	14.62	16	83.9		4,475
1922–23	70	7.80	8	20.7		6,385
1923–24	10	1.39	2	1.1		12,550
1924–25	3	6.57	5	11.7		22,682
1925–26	32	8.62	12	68.3		15,449
1926–27	—	8.88	9	33.0		2,812
1927–28	9	9.05	11	41.2	220	11,402
1928–29	30	5.98	5	11.7	299	19,671
1929–30	12	1.65	2	9.3	205	15,488
1930–31	7	8.53	8	31.8	300	19,402
1931–32	247	7.25	7	45.7	225	14,447
1932–33	269	16.33	12	46.0	209	9,243
1933–34	439	2.52	2	19.5	252	10,516
1934–35	231	4.03	2	11.3	252	11,658
1935–36	14	5.85	6	5.0	453	24,130
1936–37	51	1.86	2	3.3	469	28,992
1937–38	97	10.77	9	9.6	414	18,306
1938–39	113	7.05	6	11.3	410	19,325
1939–40	35	12.22	12	54.7	182	
1940–41						

[1] Yields for 1928–37 obtained from Bureau of Agricultural Economics and those for 1938–40 furnished by Agricultural Marketing Service.
[2] From bulletins of the Census Bureau.

Control of the boll weevil by effective dusting was reflected in the percentage increase in yield in the experimental plots with both yield per planted acre and total yield in Madison Parish.—9-23-42.

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Combination Rotenone-Nicotine "Blends" for Pea Aphid Control[1]

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The pea aphid, *Macrosiphum pisi* (Kltb.), has remained a hazard to pea production in the United States since the first serious outbreak in the East over 40 years ago. Control of this insect is probably the most important entomological problem in the State of Wisconsin, where peas are grown extensively both for canning and for the production of dry peas.

Pea aphid control has been intensively investigated in Wisconsin and various other states, particularly during the last decade, but these studies have failed to produce a recommendation that has proved generally satisfactory or gained anything like general acceptance. Rotenone-bearing dusts have been recommended and extensively used in Wisconsin for the past several years. Poor control followed their use in the dry pea areas of the state in 1940 and results have been variable elsewhere. This resulted in the establishment of the present project on April 1, 1941, and its continuation through 1942.[3]

EQUIPMENT, MATERIALS AND PROCEDURES.—Standard equipment and materials were used where feasible, and the procedures were systematized and standardized as much as possible. The Agricultural Statistical Service of the Wisconsin Agricultural Experiment Station rendered valuable aid in designing the field experiments and analyzing the results obtained.[4]

The duster used throughout was a *Bean* machine with a dust-mixing hopper, 1941 circular model distributor head, 18 nozzles on a 23-foot boom, head apron and trailer apron. The latter was 100 feet long but usually was doubled to form a 50-foot apron in 1941; in 1942 it was cut to 50 feet. The entire unit was mounted on a ton and a half truck. Weather instruments included maximum-minimum recording thermometers, rain gauges, and a recording four-cup anemometer. All aphid collections were made with the aid of fumigating funnels, using methyl iso-butyl ketone as the fumigant (Gray & Schuh 1941).

All nicotine compounds used were manufactured by the Tobacco By-Products and Chemical Corporation. In this category were 99 per cent nicotine alkaloid (not less than 99 per cent nicotine), *Black Leaf 10 Dust Base* (10 per cent by weight of nicotine alkaloid on ground tobacco base), *Black Leaf 155* (14 per cent nicotine) a proprietary fixed nicotine compound, *Black Leaf 12 Dust Base* (an experimental "semi-fixed" nicotine preparation), and *Black Leaf 40* (a proprietary nicotine sulphate containing 40 per cent nicotine).

Two different lots of cube, containing 4.6 per cent and 5.4 per cent of rotenone respectively, were furnished by McConnon & Company and used throughout the experiments reported. Pea Aphid Committee Standard Derris Powder and Standard Dust (1 per cent rotenone) were used in some of the preliminary experiments in 1941. *McConnon Super Dust* (58-G) was used as the "standard" rotenone dust in 1942 because of its popularity and extensive commercial use in the Middle West. Two commercial thiocyanate insecticides were used: *Lethane 60* (Röhm & Haas Company) and 93 per cent *Lorol* thiocyanate (E. I. du Pont de Nemours & Company, Inc.)

A variety of diluents and supplements were used in the formulae given in tables 2, 4 and 6, and others not recorded here. *Pyrax ABB* (R. T. Vanderbilt Company) was the "standard" diluent throughout this investigation. Other diluents included three brands of hydrated lime, two bentonite clays, and *Swan Brand* dusting sulphur. Hygroscopic "conditioning agents"

[1] Approved for publication by the Director of the Wisconsin Agricultural Experiment Station. Early publication of this paper has been secured by payment of the printing charges.

[2] A. A. Bertagnolli and Paul Leonard were research assistants in 1941, and L. W. Holm and L. F. Janke served in the same capacities in 1942. Many other individuals have made important contributions to the progress and welfare of this work. The cooperation and assistance of Dr. John Alsterlund and Ruth Leopold Holm are hereby accorded special acknowledgment.

[3] Wisconsin Agricultural Experiment Station Project No. 621, Scotch Pea Insect Investigations. Financed in part by Industrial Fellowships from the Tobacco By-Products and Chemical Corporation, the Joseph Campbell Company, and McConnon and Company in 1941, and the Tobacco By-Products and Chemical Corporation and McConnon and Company in 1942.

[4] This contribution of Professor Churchill Eisenhart and his assistants is gratefully acknowledged.

included *Curbay-X* and *Vacatone*, two dried distillers molasses residuum products (U. S. Industrial Chemicals, Inc.); and two paper-mill by-products, *Bindarene Flour* (International Paper Co.) and *Goulac* (American Gum Products Co.).

All field experiments were laid out in randomized block arrangements. Each treatment was used in duplicate plots in each experiment in 1941, and in quadruplicate plots in 1942. An individual plot (replicate) consisted of a single 23-foot swath across the field. The plot size varied from about 0.10 acre in some fields to 0.40 acre in others.

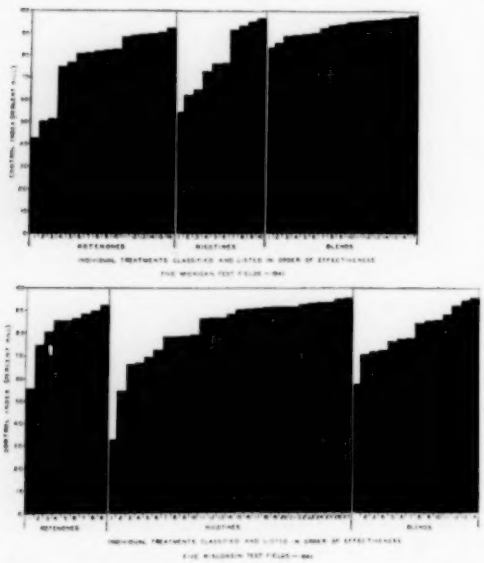

FIG. 1.—Composite results of five pea aphid control experiments in Wisconsin (below), and of five later experiments in Upper Michigan (above)

Aphid collections were made from each plot before treatment, and two, three or four times afterward, as indicated in tables 2, 4 and 6. The before-treatment collections were found to be important, due to variations in numbers from plot to plot, in even the most uniform fields. When possible they were taken on the day of treating—otherwise one or at most two or three days in advance.

Twenty-five 8-inch terminals comprised a sample for an individual plot. The procedure suggested by Gray & Schuh (1941) was altered in that one man carried two fumigating funnels, while another collected the terminals at random from the length of the plot. In this way the sample from one plot was being fumigated while the next one was being collected. The insects were killed soon after collecting by putting a pinch of calcium cyanide into each carton, in order to keep predators from reducing the counts. The samples were kept in a cool place and counted as soon as feasible. Counting was done indoors with the samples spread out on a table under artificial light, thus making for working comfort and accurate counts.

EXPERIMENTS AND RESULTS IN 1941.—The work on this project in 1941 was guided largely by the following premises: "(1) Rotenone-bearing dusts in their present state of development do not constitute a satisfactory recommendation for pea aphid control on field peas in Northeastern Wisconsin. (2) The most promising possibility for immediate investigation is the blending or combining of two or more contact insecticides into a single dust, with the hope of obtaining a synergistic action." The first of these was based on extensive commercial and limited experimental results in 1940; the second has been confirmed by subsequent results and developments.

Field work was started in Wisconsin in Door and Kewaunee Counties on June 2 and continued through July 5, after which the investigation was continued in Chippewa County, Michigan, through the month of July.[1] None of the Wisconsin results are being presented in detail, although the trend observed in five of the better experiments is shown in figure 1.

The most important contribution in 1941 was the clear-cut demonstration that combination dusts or "blends" of rotenone-bearing materials and alkaloidal nicotine are potent insecticides for pea aphid control when they are properly prepared. This lead was obtained early in the field work and was followed persistently throughout the season. Blends were included in every experiment, beginning with the third, and in this way the inferior ones were discarded and better ones developed.

In almost all of the experiments there were at least two conditioned rotenone-bearing dusts and two nicotine dusts under test in comparison with the blends. The rotenone dusts contained either 0.75 or 1.0 per cent rotenone, while the nico-

[1] The Upper Michigan experiments both in 1941 and 1942 were carried out with the approval and cooperation of the Director and the Department of Entomology of Michigan State College. The object was to extend the season of productive work in the field, and it was admirably fulfilled both seasons.

tine dusts contained from 2.4 to 4.0 per cent of actual nicotine. Therefore, adequate "yardstick" treatments were included in all experiments. Control plots were always present but were usually dusted with a light application of hydrated lime in 1941, instead of being left untreated (this was not true in 1942).

Figure 1 suggests that the nicotine dusts, as a class, were superior to both rotenone dusts on the one hand and rotenone-nicotine blends on the other, in the Wisconsin experiments. It should be pointed out, however, that practically all of these applications were made with a 100-foot apron at a duster speed of 1.15 miles per hour, whereas both the rotenone dusts and the blends were applied with a 50-foot apron at a speed of 2.3 miles per hour. (In all subsequent work a 50-foot apron was used and the duster speed was standardized at 2.3 miles per hour for all treatments, including nicotine dusts in the Michigan tests in 1941). The Wisconsin graph indicates little choice between the rotenone dusts and the blends under the conditions specified.

MICHIGAN EXPERIMENTS IN 1941.—A series of eight treatments was set up for intensive and repeated comparative testing in Michigan on the basis of the Wisconsin experiments. It included three rotenone-nicotine blends, two nicotine dusts, two conditioned rotenone-bearing dusts, and the hydrated lime control. The complete formulae of all of these dusts are included in table 2. M-1 is the hydrated lime control, M-2 and M-5 are the two 0.75 per cent rotenone dusts, M-3 and M-4 are the two nicotine dusts, and M-6, M-7 and M-8 are the three blends. It should be noted that the proportions of the two toxicants in the three blends were calculated on the basis of combining a 0.75 per cent rotenone dust and a 3.4 per cent nicotine dust in ratios of 3:1, 2:2, and 1:3, respectively.

This series of eight treatments was applied in duplicate plots in four different Michigan experiments in 1941. The results are summarized in table 2, and the significance of the differences in control reported are available in table 3. In addition, these results and the results from a fifth experiment, in which some of these formulae and certain others closely related to them were used, are presented graphically in figure 1.

The results show that the blends, particularly M-7 and M-8, were markedly superior to the conditioned rotenone dusts on the one hand and the nicotine dusts on the other, under the conditions of these experiments. (In general, the plants were succulent and the aphids apparently were healthy and viable. The days were warm but nights were cool and usually accompanied by heavy dews.) It was quite evi-

FIG. 2.—Composite results of six pea aphid control experiments in 1942. Formulae of dusts 1a to 8a inclusive are given in table 4. The formulae of dusts 1 to 8 inclusive were identical to 1a to 8a, respectively, except they were prepared with 99% nicotine alkaloid (not less than 99% nicotine), instead of *Black Leaf 10 Dust Base*. The 0.75% rotenone-bearing dust used as a basis of comparison was *McConnon Super Dust*. The poundages given are averages for the six experiments, expressed in pounds per acre.

dent that these differences were too clear-cut and consistent to be due to chance, and this was confirmed by the statistical analyses.

The two rotenone-bearing dusts in this series were designed to fulfill two roles: (1) to serve as "yardsticks" for the blends, and (2) to compare a formula supplemented with a hygroscopic agent (*Curbay X*) plus sulphur with one conditioned with SAE 10 lubricating oil. Figure 1 shows considerable variation in results with the two rotenone dusts in the Michigan experiments, and a relatively poor showing in comparison with the blends.[1] The com-

[1] In fairness to the rotenone dusts, it should be emphasized that all the after-treatment counts (first, second, fourth and sixth days) were used in calculating the controls obtained with all treatments. It may be argued that this is not entirely fair to a slow-acting insecticide like rotenone or even a quick-killing agent like nicotine. These results have also been calculated separately for the combined one- and two-day counts and the combined four- and six-day counts. In general, the former calculation favored the nicotine dusts and the latter the rotenone dusts, but most of the differences were surprisingly small, particularly where the control was fairly good. Rotenone-nicotine blends appear to combine to an encouraging degree the prompt but transitory action of nicotine with the somewhat more lasting action of rotenone. Taking everything into consideration, we feel that the procedure followed gives a fair basis of comparison of these three dust classes. It was also followed in 1942, when *McConnon Super Dust* was used as the standard rotenone-bearing dust.

parison between the two formulae was inconclusive; M-2 excelled M-5 in two experiments, while the order was reversed under the conditions of a third test. Quite different results might have been obtained under more arid conditions.

The two nicotine dusts were also formulated to serve two purposes: (1) to furnish nicotine "yardsticks" for the blends, and (2) to compare a 3.4 per cent nicotine dust with a parallel formula containing only 2.4 per cent nicotine, supplemented with approximately 1.0 per cent *Lorol* thiocyanate. Under the conditions (all treatments applied with a 50-foot trailer apron and a duster speed of 2.3 miles per hour) the nicotine dusts also gave results that stamped them as inferior to the blends. The variation shown within this class was due primarily to differences in pounds per acre applied, rather than to differences between the two formulae. Dust M-4 (the nicotine-thiocyanate combination) excelled M-3 in three comparisons out of the four, but the order was reversed in the fourth experiment. None of these differences were found significant.

SUMMARY OF RESULTS IN MICHIGAN IN 1941.—In the first three experiments dusts M-6, M-7 and M-8 stood out above all other treatments. In Experiment X dusts M-7 and M-8 were again at the top, and M-6 was excelled only by them and the two nicotine dusts, all of which gave well over 90 per cent control. The analysis of variance tables compiled by the Station Statistician for each experiment showed a significant variation "between test dust types" in every instance. Table 3 shows that, with two exceptions, both M-7 and M-8 were significantly superior to all other treatments except M-6 in every comparison. The "high-rotenone blend," M-6, evidently was slightly inferior to the other two, although it did not differ significantly from either M-7 or M-8 in two experiments out of the four. These data seem to disprove the hypothesis that nicotine serves merely as a good rotenone activator in rotenone-nicotine blends.

In table 1 is a composite analysis of variance table for the seven treatments that were common to the four Michigan experiments (M-5 was not used in experiment VII because of space limitations):

Table 1.—Composite analysis of variance on four Michigan experiments.

VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE (VARIANCE)	"F"
Fields	3	1.4044	0.4681	2.351
Between all dusts	6	42.5379	7.0896	35.608†
Control vs. test dusts	1	23.6194	23.6194	118.631†
Between test dusts	5	18.9185	3.7837	19.004†
Between test dust classes	2	15.8718	7.9359	39.859†
Within test dust classes	3	3.0467	1.0156	5.101*
Field×dusts	18	4.5372	0.2521	1.266
Blocks	4	0.8103	0.2026	1.018
Error	24	4.7795	0.1991	
Total	55	54.0693		

* Indicates significance at the 5% level. † Indicates significance at the 1% level.

This table shows that the dusts did not have significantly different effects on the different fields, *i.e.*, the "fields × dusts" variation was not statistically significant. However, the various dusts had significantly different effects, and the dust classes (rotenones, nicotines, and blends) varied significantly. The variation within test dust classes was significant at the five per cent level. As expected, the test dusts were significantly different from the hydrated lime control. The variation between fields and that between blocks were found to be non-significant.

EXPERIMENTS AND RESULTS IN 1942.—Most of the emphasis in 1942 was placed on further studies of the rotenone-nicotine blends under field conditions. The object was to substantiate the results obtained in 1941, and to answer some of the practical questions that arose regarding the blends following the 1941 season. The problems of insecticidal, physical and chemical deterioration in storage; importance of a hygroscopic agent and sulphur as supplements; effectiveness under

adverse weather conditions; and certain new variations and combinations of toxic ingredients, received most of the emphasis. All of the blends tested in 1942 were of the "half-and-half" type represented by M-7 in 1941, *i.e.*, they theoretically contained approximately 0.375 per cent rotenone and 1.7 per cent nicotine. Experiments were conducted on canning peas in Wisconsin and on Canadian field peas in Upper Michigan.

The results of four Michigan experiments are presented in tables 4 and 5, and these results plus those of two Wisconsin experiments are presented graphically in figure 2. Two additional Michigan experiments are reported in tables 6 and 7. The others were either designed to answer special questions or were unsatisfactory as experiments, and consequently are omitted here. The Wisconsin experiments were far less satisfactory than those in Michigan, due to rainy and humid weather and prevalence of fungus disease.

A set of formulae were mixed in the *Bean* machine on December 6, 1941, and held in unheated storage until used during the 1942 season. In tables 4 and 5 and figure 2 the results with these stored blends are compared with those obtained with freshly-mixed dusts of identical composition.

WHAT IS THE EFFECT OF PROLONGED STORAGE UPON ROTENONE-NICOTINE BLENDS?—Three points are involved in this question: (1) loss of insecticidal efficiency, (2) physical deterioration, and (3) loss of nicotine.

The effect of storage upon the insecticidal efficiency of the blends is clearly evident in tables 4 and 5 and figure 2. Dusts 1a and 5a, 2a and 6a, 3a and 7a, and 4a and 8a, respectively, were identical, except for the time of mixing (see formulae in table 4). The complete formula, 5a, compared quite favorably after storage with all of the freshly-prepared blends. However, the three stored dusts in which one or both supplements were lacking (6a, 7a and 8a) were definitely inferior to the others. This was particularly true of dust 8a, which lacked both *Curbay-X* and sulphur. Evidently rotenone-nicotine blends have a tendency to deteriorate in storage. However, none of them were rendered impotent by storage and the complete formula remained a superior dust throughout these experiments.

The standard blend in 1942 contained only 10 per cent each of *Curbay-X* and sulphur, instead of 20 per cent as in 1941. The object was primarily to reduce the tendency to cake during storage, and secondarily to reduce the cost. The physical properties of this and other blends were quite ideal when they were freshly prepared, but 10 per cent of *Curbay-X* caused some caking during storage in all containers tested. This was not serious in either the fiber or the steel drums, but it was important when dusts 5a and 7a were stored in "moisture-proofed" (asphalted) paper-lined cloth bags. Also, these dusts tend to "gum" in dusting equipment during moist weather. Lower concentrations or another choice of hygroscopic agent should solve this problem.

Nicotine analyses of some of the stored blends were made to determine the nicotine loss from the various containers used. These results indicate that 10 per cent of sulphur in the formula will reduce but not entirely eliminate the loss of nicotine from a rotenone-nicotine blend.

ARE SULPHUR AND A HYGROSCOPIC AGENT NECESSARY FOR BEST RESULTS WITH ROTENONE-NICOTINE BLENDS?—Both dusting sulphur and a hygroscopic agent were included in the standard blends in 1942, because the work had not been carried far enough in 1941 to show whether or not both are necessary for best results. The hygroscopic material was originally included on the theory that it might increase the toxicity of the rotenone component; the sulphur on the hypothesis that it might aid the action of both rotenone and nicotine.

Formulae 1a to 8a inclusive in table 4 were compounded to give information on two practical points: (1) the deterioration of rotenone-nicotine blends in storage, and (2) the importance of sulphur and a hygroscopic agent as supplements in these dusts. Dusts 1a and 5a are complete formulae, 2a and 6a contain 10 per cent sulphur but lack *Curbay-X*, 3a and 7a contain 10 per cent *Curbay-X* but lack sulphur, and 4a and 8a lack both *Curbay-X* and sulphur.

Tables 4 and 5 and figure 2 show that formulae 1a, 2a, 3a and 4a all gave excellent control when they were used soon after mixing. These results indicate that such dusts are somewhat improved by the addition of a hygroscopic agent but not

Table 2.—Summary of pea aphid control obtained with eight treatments applied in duplicate in four different experiments on field peas in 1941. (All dusts mixed in hopper of *Bean* machine just before application. A 50-foot apron was used and duster speed was 2.3 miles per hour for all treatments.)

Dust					Live Aphids[1]		Control[2]	
No.	Composition	Experiment	Lbs. per Acre	Temp. °F.	Before Treatment	After Treatment	Arithmetic Calculation	Geometric Calculation
M-1	Control: a light application of hydrated lime, except in Experiment X where it was untreated	VII	15±	74.0	4112	2250	0	0
		VIII	15±	70.5	3552	3110	0	0
		IX	15±	66.5	1776	1066	0	0
		X	0	—	4416	4812	0	0
M-2	18.04 lbs. *Pyrax ABB*	VII	39.8	75.0	3808	431	79.3	82.6
	8.0 lbs. *Curbay-X*	VIII	29.9	73.0	3112	488	82.1	82.2
	8.0 lbs. dusting sulphur	IX	39.0	71.5	928	285	48.8	51.0
	5.56 lbs. cube (5.4% rot.)	X	37.7	81.0	4448	1048	78.4	76.6
	0.4 lb. oil (*Sinclair Insecticide* Base)							
M-5	34.04 lbs. *Pyrax ABB*	VII	—	—	—	—	—	—
	5.56 lbs. cube (5.4% rot.)	VIII	31.9	73.0	5456	1207	74.7	74.9
	0.4 lb. SAE 10 lubricating oil	IX	41.9	73.0	1520	468	48.7	49.9
		X	46.2	81.0	5008	653	88.0	89.8
M-3	33.0 lbs. hydrated lime	VII	34.4	75	4888	712	73.4	72.5
	17.0 lbs. *Black Leaf 10 Dust Base*	VIII	29.9	78.5	1944	1043	38.7	54.3
		IX	50.0	72.5	1248	291	61.2	62.0
		X	48.5	79.5	4800	384	92.7	93.8
M-4	32.5 lbs. hydrated lime	VII	33.6	75.5	4320	563	76.2	76.6
	5.0 lbs. *Curbay-X*	VIII	27.8	78.0	3392	975	67.2	64.5
	12.0 lbs. *Black Leaf 10 Dust Base*	IX	50.0	72.0	1520	195	78.6	76.0
	0.5 lb. 93% *Lorol* thiocyanate	X	54.6	75.5	2532	291	89.5	91.5
M-6	24.36 lbs. *Pyrax ABB*	VII	40.6	75.0	5664	527	83.0	83.4
	10.0 lbs. *Curbay-X*	VIII	34.0	71.0	4328	203	94.6	94.2
	10.0 lbs. dusting sulphur	IX	52.9	70.0	1680	154	84.8	85.5
	5.21 lbs. cube (5.4% rot.)	X	56.5	78.0	4824	498	90.5	90.2
	0.425 lb. 99% nicotine alkaloid							
M-7	25.68 lbs. *Pyrax ABB*	VII	52.3	74.5	4424	139	94.3	94.0
	10.0 lbs. *Curbay-X*	VIII	34.0	71.0	6048	219	95.9	95.3
	10.0 lbs. dusting sulphur	IX	52.9	68.5	1896	103	91.0	92.6
	3.47 lbs. cube (5.4% rot.)	X	63.1	75.5	5016	119	97.8	98.1
	0.85 lb. 99% nicotine alkaloid							
M-8	26.99 lbs. *Pyrax ABB*	VII	46.9	74.0	3464	76	96.0	95.7
	10.0 lbs. *Curbay-X*	VIII	38.2	72.0	4992	224	94.9	96.0
	10.0 lbs. dusting sulphur	IX	40.4	73.0	1520	110	87.9	88.8
	1.735 lbs. cube (5.4% rot.)	X	52.3	80.0	5104	149	97.3	97.4
	1.275 lbs. 99% nicotine alkaloid							

[1] Number of live aphids in all cases indicates the count for samples collected from 50 terminals, using the fumigating funnels. Th after-treatment count in this table is the arithmetic average of four collections made on the first, second, fourth and sixth (or seventh) days respectively after treatment.

[2] The control index or "per cent kill" was calculated arithmetically by the so-called Abbott formula, $\frac{x-y}{x}\times 100$, where "x" represents the per cent reduction in the control plot and "y" the per cent reduction in the treated plot (the mean of the four after-treatment collections was used in each case). A similar calculation was based on the geometric mean, using logarithms and antilogs, according to the formula: control index $= \frac{(\text{antilog of control}) - (\text{antilog of dust})}{(\text{antilog of control})} \times 100$.

by the use of sulphur. However, when these same formulae were fall-mixed and used after storage (dusts 5a, 6a, 7a, and 8a), the use of both sulphur and the hygroscopic agent seemed necessary for best results. Omission of either supplement decreased the effectiveness, and omission of both resulted in a comparatively poor dust after storage.

Summarizing, rotenone-nicotine blends

Table 3.—Condensed plus and minus chart showing the significance of the differences in results with the treatments reported in table 2.[1] (A "plus" sign indicates a significant difference at the 5 per cent level, while a "minus" indicates a non-significant difference. Refer to table 2 to determine the *sign* of the difference, *i.e.*, which is the better dust.[2])

	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8
M-1		+− ++	+− −+	++ −+	− ++	++ ++	++ ++	++ ++
M-2	+− ++		−− −+	−− −+	− −+	−+ ++	−+ ++	++ ++
M-3	+− −+	−− −+		−− −−	− −−	−− +−	++ ++	++ ++
M-4	++ −+	−− −+	−− −−		− −−	−− +−	++ ++	+− ++
M-5	− ++	− −+	− −−	− −−		+ +−	+ ++	+ ++
M-6	++ ++	−+ ++	−− +−	−− +−	+ +−		−− −+	+− −+
M-7	++ ++	−+ ++	++ ++	++ ++	+ ++	−− −+		−− −−
M-8	++ ++	++ ++	++ ++	+− ++	+ ++	+− −+	−− −−	

[1] Based on the 5% minimal significant difference calculated from the error mean square of the appropriate analysis of variance tables. Condensed from four tables prepared by the Wisconsin Agricultural Statistical Service. Since the 5% level of significance was employed, it follows that about 5% of the plus signs may be due to chance instead of real differences.

[2] The following is the order of recording these signs: Experiment VII is given in the upper left corner of the respective squares; Experiment VIII in the lower left; Experiment IX in the upper right; and Experiment X in the lower right.

should contain some sulphur (10 per cent is considered adequate) if they are to be pre-mixed and stored prior to application. If they are used immediately after mixing (as is possible with a *Bean* machine) sulphur may be omitted. A hygroscopic agent is desirable in both fresh-mixed and stored blends, but those tested to date have resulted in caking during storage. These included *Curbay-X*, *Vacatone* and *Goulac*, all used at 10 per cent in 1942.[1]

HOW DO THE ROTENONE-NICOTINE BLENDS PERFORM UNDER ADVERSE CONDITIONS?—Special efforts were made in 1942 to test the rotenone-nicotine blends under adverse conditions, and the results obtained under such conditions were most encouraging. These included (1) low temperatures, (2) high wind while dusting, and (3) very hardy aphid populations.

In Experiment V the series of eight blends and *McConnon Super Dust* were applied within a temperature range of 50° to 61° F. The first two formulae were applied at 50° F., yet the kills were calculated at 97.1 per cent and 95.6 per cent respectively. Other experiments were conducted in Upper Michigan in which lower-than-average temperatures prevailed during and after treatment. In spite of this the blends as a class continued to give entirely satisfactory results. This is indeed gratifying, since both conditioned rotenone-bearing dusts and plain nicotine dusts are apt to give erratic results under such conditions.

In Experiment IV all blends with the possible exception of 2a were applied at average wind velocities of 9 or more miles per hour. The recording instrument probably gave conservative readings, because the wind at times was strong enough to whip the 50-foot apron while these dusts were being applied. Yet every one of them gave results in accordance with their performances in other experiments. An unreported experiment was applied under even more windy conditions and others were applied on moderately windy days, but the blends consistently gave superior

[1] Both *Curbay-X* and *Vacatone* have been extensively tested in the field and apparently can be used interchangeably without altering either the physical properties or the effectiveness of the dusts. *Goulac*-containing blends have not been tested in the field.

Table 4.—Summary of pea aphid control obtained with eleven treatments applied in quadruplicate in four different experiments on field peas in 1942. (Dusts 1a, 2a, 3a, 4a and 12 mixed in hopper of *Bean* machine just before application. A 50-foot apron was used and duster speed was 2.3 miles per hour for all treatments.)

Dust		Experiment	Lbs. per Acre	Temp. °F.	Live Aphids[1]		Control[2]	
					Before Treatment	After Treatment	Calculation	
No.	Composition						Arithmetic	Geometric
11	Control: untreated	III	—	—	5272	3322	0	0
		IV	—	—	7520	3707	0	0
		V	—	—	1792	2015	0	0
		VI	—	—	7264	3866	0	0
1a	28.03 lbs. *Pyrax ABB* 5.0 lbs. dusting sulphur 5.0 lbs. *Curbay-X* 3.47 lbs. cube (5.4% rotenone) 8.5 lbs. *Black Leaf 10 Dust Base*	III	41.2	83	7748	232	95.3	96.2
		IV	48.4	82	6904	219	93.6	94.2
		V	53.3	50	2304	88	96.6	97.1
		VI	53.3	84	5784	172	94.4	94.4
2a	33.03 lbs. *Pyrax ABB* 5.0 lbs. dusting sulphur 3.47 lbs. cube (5.4% rotenone) 8.5 lbs. *Black Leaf 10 Dust Base*	III	51.5	83	5436	242	92.9	94.4
		IV	42.7	81	6528	402	87.5	88.3
		V	57.8	50	2264	150	94.1	95.6
		VI	56.7	84	5776	129	95.8	96.2
3a	33.03 lbs. *Pyrax ABB* 5.0 lbs. *Curbay-X* 3.47 lbs. cube (5.4% rotenone) 8.5 lbs. *Black Leaf 10 Dust Base*	III	50.7	84	5704	115	96.8	97.4
		IV	49.2	80	8312	261	93.6	94.0
		V	42.2	52	2040	184	92.0	92.8
		VI	53.3	84	7104	149	96.1	96.5
4a	38.03 lbs. *Pyrax ABB* 3.47 lbs. cube (5.4% rotenone) 8.5 lbs. *Black Leaf 10 Dust Base*	III	48.5	86	5144	207	93.6	93.7
		IV	45.2	82	8024	320	91.9	91.9
		V	64.4	56	2208	399	83.9	83.0
		VI	55.0	84	7304	242	93.8	95.0
5a	Same formula as No. 1a, but mixed Dec. 6, 1941, and stored until used	III	49.3	85	5632	278	92.2	93.7
		IV	45.2	80	8032	305	92.3	92.6
		V	55.6	60	2344	343	87.0	87.7
		VI	65.0	84	6704	446	87.5	87.7
6a	Same formula as No. 2a, but mixed Dec. 6, 1941, and stored until used	III	47.1	86	5144	614	81.1	79.6
		IV	46.8	80	6584	732	77.4	78.1
		V	55.6	61	1632	415	77.4	78.6
		VI	56.7	84	6576	783	77.6	76.6
7a	Same formula as No. 3a, but mixed Dec. 6, 1941, and stored until used	III	50.7	86	4592	519	82.1	81.8
		IV	51.6	82	6256	752	75.6	77.1
		V	53.3	61	2132	512	78.6	79.6
		VI	61.7	84	7416	1001	74.6	75.5
8a	Same formula as No. 4a, but mixed Dec. 6, 1941, and stored until used	III	53.7	86	5888	958	74.2	76.0
		IV	51.6	81	8632	1025	75.9	78.1
		V	52.2	61	2040	559	75.6	77.1
		VI	58.3	84	6632	1147	67.5	67.6
9	*McConnon Super Dust* (58-G; 0.75% rotenone)	III	46.3	82	6104	753	80.4	81.4
		IV	40.3	69	9088	1386	69.1	72.5
		V	51.1	61	2553	632	78.0	79.1
		VI	51.7	84	6616	803	77.2	82.2
12	48.07 lbs. *Pyrax ABB* 0.93 lb. cube (5.4% rotenone) 1.00 lb. *Lethane 60*	III	54.4	86	5544	416	88.1	89.0
		IV	41.1	70	8344	930	77.4	79.1
		V	51.1	63	2054	539	76.7	80.0
		VI	—	—	—	—	—	—

[1] Number of live aphids in all cases indicates the count for samples collected from 100 terminals, using the fumigating funnels. The after-treatment count in this table is the arithmetic average of the two or three collections made after treatment. These were made as follows: Experiment III, second and fifth days; Experiment IV, first, fourth and sixth days; Experiment V, first and fourth days; Experiment VI, first, third and fifth days.

[2] See next page.

Table 5.—Condensed plus and minus chart showing the significance of the differences in results with the treatments reported in table 4.[1] (A "plus" indicates a significant difference at the 5 per cent level, while a "minus" indicates a non-significant difference. Refer to table 4 to determine the sign of the difference, *i.e.*, which is the better dust.)[2]

	1a	2a	3a	4a	5a	6a	7a	8a	9	11	12
1a		−−	−+	−+	−+	++	++	++	++	++	++
		+−	−−	−−	−+	++	++	++	++	++	+
2a	−−		−−	−+	−+	++	++	++	++	++	−+
	+−		+−	−−	−+	++	++	++	++	++	+
3a	−+	−−		++	+−	++	++	++	++	++	++
	−−	+−		−−	−+	++	++	++	++	++	+
4a	−+	−+	++		−−	+−	+−	+−	+−	++	−−
	−−	−−	−−		−+	++	++	++	++	++	+
5a	−+	−+	+−	−−		+−	+−	+−	−+	++	−−
	−+	−+	−+	−+		++	++	++	−+	++	+
6a	++	++	++	+−	+−		−−	−−	−−	++	−−
	++	++	++	++	++		−−	−−	−−	++	−
7a	++	++	++	+−	+−	−−		−−	−−	++	−−
	++	++	++	++	++	−−		−−	−−	++	−
8a	++	++	++	+−	+−	−−	−−		−−	++	−−
	++	++	++	++	++	−−	−−		−+	++	−
9	++	++	++	+−	+−	−−	−−	−−		++	−−
	++	++	++	++	+−	−−	−−	−+		++	−
11	++	++	++	++	++	++	++	++	++		++
	++	++	++	++	++	++	++	++	++		+
12	++	−+	++	−−	−−	−−	−−	−−	−−	++	
	+	+	+	+	+	−	−	−	−	+	

[1] Based on the 5 per cent minimal significant difference calculated from the error mean square of the appropriate analysis of variance tables. Condensed from four tables prepared by the Wisconsin Agricultural Statistical Service. Since the 5 per cent level of significance was employed, it follows that about 5 per cent of the plus signs may be due to chance instead of real differences.

[2] The following is the order of recording these signs: Experiment III is given in the upper left corner of the respective squares; Experiment IV in the lower left; Experiment V in the upper right; and Experiment VI in the lower right.

results. However, dusting for pea aphid control should be avoided during windy weather, if possible, regardless of the material used.

The aphid infestations in Michigan Experiments III, IV, V, VII and VIII were no doubt fundamentally viable and healthy. This was shown by the healthy and hardy appearance of the aphids and the rate at which they were reproducing. The fungus disease was at a relatively low level in these fields and only heavy predation, mostly by syrphid larvae, was holding the infestations within reasonable limits before treatments were applied. Yet all of the rotenone-nicotine blends performed up to expectations in every one of these tests. In fact, by using the "Abbott formula" in calculating the results, they showed up to better advantage in these fields than they did in the two Wisconsin experiments where the populations were decidedly unhealthy.

WHAT FORMS OF NICOTINE ARE SATISFACTORY IN ROTENONE-NICOTINE BLENDS? —Our results to date indicate that only alkaloidal nicotine should be used in the blends. Two different forms of the alkaloid have been extensively tested in these dusts during the past two years. They

[2] (Footnote 2, Table 4, opposite page.)

The control index or "per cent kill" was calculated arithmetically by the so-called Abbott formula, $\frac{x-y}{x} \times 100$, where "x" represents the per cent reduction in the control plot and "y" the per cent reduction in the treated plot (the mean of the two or three after-treatment collections was used in each case). A similar calculation was based on the geometric mean, using logarithms and antilogs, according to the following formula: control index = $\frac{\text{(antilog of control)} - \text{(antilog of dust)}}{\text{(antilog of control)}} \times 100$.

Table 6.—Summary of pea aphid control obtained with seven treatments applied in quadruplicate in two different experiments on field peas in 1942. (Dusts 1b, 13 and 14 mixed in hopper of *Bean* machine just before application. A 50-foot apron was used and duster speed was 2.3 miles per hour for all treatments.)

Dust		Experiment	Lbs. per Acre	Temp. °F.	Live Aphids[1]		Control[2]	
					Before Treatment	After Treatment	Calculation	
No.	Composition (theoretical)						Arithmetic	Geometric
11	Control: untreated	VII	—	—	6144	4428	0	0
		VIII	—	—	1952	4709	0	0
1b[3]	*Pyrax ABB* diluent 10% dusting sulphur 10% *Vacatone* 1.7% nicotine 0.375% rotenone	VII	47.6	68	5080	484	86.8	87.1
		VIII	39.6	85	2774	209	96.9	97.3
9	*McConnon Super Dust* (58-G; 0.75% rotenone)	VII	41.5	72	5668	1493	63.5	66.1
		VIII	45.1	86	2338	425	92.5	93.8
13	*Pyrax ABB* diluent 10% dusting sulphur 10% *Vacatone* 1.7% nicotine 1.0% *Lethane 60* 0.187% rotenone	VII	40.9	72	6460	437	90.6	90.2
		VIII	39.0	87	2218	202	96.2	96.5
14	*Pyrax ABB* diluent 1.7% nicotine 1.0% *Lethane 60* 0.187% rotenone	VII	50.6	71	6456	413	91.1	90.9
		VIII	37.2	87	1987	310	93.5	94.1
165-H	*Pyrax ABB* diluent 2.0% *Lethane 60* 0.40% rotenone	VII	48.2	70	5616	1273	68.5	69.8
		VIII	42.7	85	2908	615	91.2	92.4
165-J	*Pyrax ABB* diluent 3.0% *Lethane 60* 0.25% rotenone	VII	43.9	70	4768	974	71.7	74.3
		VIII	39.0	81	2522	495	91.9	92.8

[1] Footnote "1" of Table 4 also applies here. Collections were made on the first, third and sixth days after treatment in both Experiment VII and Experiment VIII.
[2] Footnote "2" of table 4 also applies here.
[3] This formula is fundamentally the same as dust "1a" in tables 4 and 5, although its composition is slightly different.

were: (1) 99 per cent nicotine alkaloid (not less than 99 per cent nicotine), and (2) *Black Leaf 10 Dust Base*. All of our experience indicates that these two products will give identical results in the blends, providing (1) that equal concentrations of nicotine are present in the finished dusts, and (2) essentially the same physical properties characterize the two dusts.

Unreported experiments indicate that blends prepared with a "fixed" nicotine (*Black Leaf 155*) containing 14 per cent nicotine, and a "semi-fixed" nicotine (*Black Leaf 12 Dust Base*) are inferior to comparable formulae prepared with 99 per cent liquid alkaloid for pea aphid control. Of the two materials mentioned, *Black Leaf 155* appeared more promising than *Black Leaf 12 Dust Base*. Nicotine sulphate (*Black Leaf 40*) has been used in certain blend formulae in some of our experiments, but it is not recommended as a substitute for the alkaloid in rotenone-nicotine blends.

How Did the Rotenone-Nicotine Blends Perform in Comparison with the Other Dusts Under Test?—The dusts tested in 1942 included the 0.75 per cent rotenone "yardstick," and two classes of combination dusts besides the rotenone-nicotine blends. These included (1) rotenone-thiocyanate combination dusts and (2) "three-way" combinations of rotenone, nicotine and a thiocyanate.

The rotenone-nicotine blends as a class were superior to one of the better commercial rotenone dusts (*McConnon Super Dust* or 58-G), in spite of two pertinent facts: (1) Most of the blends were compounded without one or more basic sup-

Table 7.—Combined plus and minus chart showing the significance (at the five per cent level) of the differences in results with the seven treatments reported in table 6. (The upper sign is for Experiment VII; the lower one for Experiment VIII.)

	1b	9	11	13	14	165-H	165-J
1b		+	+	−	−	+	+
		+	+	−	+	+	+
9	+		+	+	+	−	−
	+		+	−	−	−	−
11	+	+		+	+	+	+
	+	+		+	+	+	+
13	−	+	+		−	+	+
	−	−	+		−	+	+
14	−	+	+	−		+	+
	+	−	+	−		−	−
165-H	+	−	+	+	+		−
	+	−	+	+	−		−
165-J	+	−	+	+	+	−	
	+	−	+	+	−	−	

plementary ingredients (to determine which ones may be eliminated), and some of them obviously had deteriorated as a result of experimental storage. (2) Several blend formulae were of an exploratory nature, and, as was to be expected, some of them gave comparatively poor results. On the other hand, it has been pointed out that the method used to calculate the control slightly penalizes a rotenone dust for its slow action. The trend of these results is evident from tables 4, 5, 6, and 7 and figure 2.

Three different dusts containing ground cube root and *Lethane 60* (an aliphatic thiocyanate) were tested in 1942. Dust 12 of tables 4 and 5 is a cheap formula of this type which gave a fairly good account of itself when it was freshly-prepared and used in experiments III, IV and V. In every case it excelled treatment 9 (0.75 per cent rotenone), but it was, in turn, consistently excelled by blends 1a, 2a, 3a, 4a and 5a. Table 5 shows that none of the recorded differences between 9 and 12 were significant; whereas, in 10 cases out of 15, the above-mentioned rotenone-nicotine blends were significantly better than number 12.

The results with the other two rotenone-thiocyanate combination dusts, 165-H and 165-J, are presented in tables 6 and 7. These were factory-made by McConnon and Company, and kept a few weeks before testing. Both excelled treatment 9 (0.75 per cent rotenone) in Experiment VII, and were excelled by it in Experiment VIII. None of these differences were significant, according to table 7. On the other hand, a standard rotenone-nicotine blend, formula 1b, was significantly better than either of these combinations in both experiments.

Several "three-way" combination dusts containing cube, alkaloidal nicotine, and a thiocyanate insecticide gave promising indications in 1942. Dusts 13 and 14 of tables 6 and 7 were of this type, and 13, at least, was about on a par with the standard rotenone-nicotine blend when used immediately after mixing, according to the results presented. These formulae are of particular interest at this time because they contained only half as much rotenone as the blends, *i.e.*, theoretically 0.187 per cent.

Certain cheap three-way combination dusts were formulated on the basis of the results obtained with dusts 13 and 14. They contained still lower concentrations of rotenone and nicotine, but gave favorable indications when freshly prepared and used in preliminary tests. *Rotenone-nicotine-thiocyanate combination dusts certainly merit further consideration, but none of them are suggested for even limited commerical use until further experimental results are available.*

WHAT PROBLEMS DO THE ROTENONE-NICOTINE BLENDS PRESENT FOR FURTHER INVESTIGATION?—These dusts are being recommended for pea aphid control in

Wisconsin in 1943, but this does not mean that all of the practical problems involved have been solved. Among the more important of these are questions relating to hygroscopic agents, diluents and containers.

The best hygroscopic agent to use and the optimum concentration of it are still to be determined. Pending further investigation, it seems advisable to use a hygroscopic material such as *Vacatone* in concentrations of 1 to 2 per cent. Pyrophyllite would be entirely satisfactory as a diluent, were it not for its abrasive properties. Other inert diluents such as talc or gypsum would probably prove satisfactory, but adequate evidence on this point is lacking. Steel drums would be the ideal containers, but they are not now available for this use. Moisture-proofed (asphalted) paper-lined cloth bags or sealed fiber drums are suggested as the best substitutes available.

Other problems may require attention when these dusts are introduced commercially. More needs to be known about deterioration in storage, for example. These dusts have a characteristic pungent odor that is disagreeable to operators and may prove irritating to horses on horse-drawn machines. Our experience does not indicate that they are any more hazardous to either higher animals or plants than ordinary rotenone-bearing dusts. Better mixing methods may be developed. Our procedure with the *Bean* machine was first to mix the dry ingredients thoroughly (best results were obtained by putting the lightest ingredient in the bottom of the hopper), and add the liquids, if any, in a small stream while agitating slowly by holding the clutch part way in: then agitating at full speed for several minutes with the hopper closed.

PREVIOUS USE OF ROTENONE-NICOTINE COMBINATIONS.—Combination dusts containing rotenone and nicotine are not a new idea in insect control, but their inherent possibilities apparently have not been fully appreciated or utilized heretofore. This whole idea was completely covered by a British patent issued in 1925, and consequently now expired (McDougall & Howles 1925). This patent claims that when nicotine is combined in a dust with either extracts or ground roots of plants of the Dalbergiae tribe and Derris family, the mixture "has greater insecticidal properties than would be expected having regard to the separate quantities of the insecticidally active materials used." A different but significant claim is made in a United States patent issued in 1935, which covers the combination of veratrin (another alkaloid, or really a mixture of alkaloids) with rotenone-bearing materials (Schotte & Görnitz 1935). It claims that "an insecticidal effect is obtained, which is far greater than the effects exerted by the two drugs if used singly."

Insecticidal mixtures containing rotenone and nicotine as their active ingredients were used experimentally and in fact sold commercially prior to the initiation of this investigation in 1941. This combination was suggested by the writer in a plan for a proposed pea aphid investigation which was submitted to the Director of the Wisconsin Experiment Station in 1934. Dudley & Bronson ran preliminary tests with rotenone-nicotine dusts for pea aphid control in 1936 and 1937 (unpublished data). Brooks & Allen (1940) started work on combination dusts of this type for the control of cabbage insects in 1938. At least three proprietary dusts of this general description are known by the writer to have been on the market, one of them at least 5 years ago. Arnold and associates of the Tobacco By-Products and Chemical Corporation developed *Black Leaf 1050 Dust Base* (an experimental concentrate containing 10 per cent nicotine alkaloid and 2.5 per cent rotenone) in 1941, independently of any suggestions from the writer. A striking confirmation of the potency of rotenone-nicotine combinations for pea aphid control was obtained by Glasgow in 1941 when he used these two materials together in a concentrated spray (Glasgow 1942).

Most of the insecticide combinations mentioned differed from our blends in two fundamental respects. First, they contained in the finished form a heavy charge of each of the toxic ingredients, thus making them quite expensive. Our blends were made with a proportionately reduced amount of each toxicant, thus reducing the cost. A second point is that nicotine sulphate was used in most of these preparations, rather than the alkaloid. Use of the alkaloid eliminates hydrated lime and extra liquid in the formula, and perhaps has other advantages.

SUMMARY AND CONCLUSIONS.—1. The

term "blends" is introduced in the title with reference to combination insecticidal dusts containing rotenone-bearing materials and nicotine, each in proportionately reduced concentrations, as their toxic ingredients. *The writer hereby proposes that the term "blend" be restricted to this particular insecticidal combination.*

2. The rotenone-nicotine blends described in this paper, in the opinion of the writer, exhibited a true synergistic relationship between the two toxicants, at least when these dusts were used for control of the pea aphid. In other words, "the total toxic effect of the mixture appeared to be greater than the sum total of the individual effects of the two component insecticides."

3. Most of the blends described gave superior pea aphid control in comparison with standard rotenone-bearing and nicotine dusts in extensive field tests in 1941 and 1942. This held under a wide variety of conditions, including situations both favorable and unfavorable to the action of pea aphid dusts.

4. The blends may undergo insecticidal, physical and chemical deterioration during prolonged storage, but none of them have been rendered impotent by storage in our experience, and the complete formula withstood storage surprisingly well. Some supplements (sulphur and certain hygroscopic agents) markedly reduced insecticidal deterioration in storage, but did not entirely eliminate it. Some hygroscopic materials introduce problems of caking in storage, and gumming when used during moist weather.

5. Only alkaloidal nicotine should be used in the preparation of rotenone-nicotine blends for pea aphid control, but it may be introduced in either the liquid form or as *Black Leaf 10 Dust Base.* Ground cube roots have been used almost exclusively as the rotenone-bearing component.

6. An inert diluent of good physical properties should be used in the blends, and about 10 per cent of dusting sulphur should be included in the formula to reduce nicotine loss if the dusts are to be stored before use. Pyrophyllite has been the principal diluent in practically all of our formulae; hydrated lime and bentonite clays should not be used. Reduced concentrations of hygroscopic supplements are suggested, pending further investigations.

7. Some practical problems relating to the rotenone-nicotine blends and their commercial use are mentioned.

8. Rotenone-nicotine blends now have an experimental background that warrants their introduction into commercial use for pea aphid control. They are being recommended for this purpose in Wisconsin in 1943.

9. The apparent superiority of rotenone-nicotine blends for pea aphid control, coupled with the present shortage of rotenone-bearing insecticides, suggests the possibility of their utilization in other insect control problems.

10. Certain combination dusts containing reduced concentrations of ground cube root and an aliphatic thiocyanate as their toxic ingredients are about on a par with a 0.75 per cent rotenone dust, but inferior to the rotenone-nicotine blends, according to our experiments in 1942.

11. Combination dusts containing rotenone, nicotine and an aliphatic thiocyanate, all in low concentrations, show promise of controlling the pea aphid just as effectively as the blends, with still greater economy of rotenone-bearing materials and nicotine.

12. Attempts to improve rotenone dusts by supplementing them with relatively high proportions of certain hygroscopic agents; and to improve nicotine dusts by replacing 1.0 per cent of the nicotine with *Lorol* thiocyanate gave inconclusive results in 1941. These leads were not further investigated in 1942.—2-15-43.

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Methyl Bromide Fumigation for Control of the Sweetpotato Weevil and Its Effect on Yield

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Experimental work has been under way for several years to develop methods for freeing sweetpotato roots from infestation of the sweetpotato weevil, *Cylas formicarius elegantulus* (Summers). Dozier (1939) in preliminary experiments showed that methyl bromide was effective against sweetpotato weevils in the roots, and Easter (1940) found that this material was particularly adapted to the fumigation of sweetpotatoes. The question of the practicability of fumigating draws and vine cuttings instead of roots was raised by the necessity of postfumigation heating of the roots, which requires considerable equipment and expense. An additional factor making plant fumigation desirable is the possibility of draws from clean seed becoming infested while growing in the seed bed before being set in the field.

Preliminary tests on the fumigation of draws were made in 1938. In the 1939 planting season studies were begun to determine the dosage and exposure necessary to produce complete weevil mortality and to ascertain the tolerance of the sweetpotato draws to the fumigant in order to develop a treatment that could be applied under practical commercial conditions.

Fumigation Chamber.—Fumigations were conducted in a wooden chamber having a capacity of 100 cubic feet and equipped with a fan and a thermograph. A 25-cubic-foot chamber constructed of 28-gauge galvanized iron and insulated with 1.5 inches of bagasse board was also used. A thermostat mounted in this chamber, controlling strip heaters and fan, made it possible to hold the temperature constant within about 4° F.

Experiments on Weevil Mortality.—Studies on weevil mortality were conducted in the laboratory at Sunset, La., in 1939 and 1940 and were confined to small numbers of plants because of the difficulty in determining the mortality of the eggs and small larvae. In 15 tests at a dosage of 10 ounces of fumigant per 1,000 cubic feet for 4 hours at 80° F., involving 1122 fumigated plants with an estimated 630 eggs and larvae, and 725 check plants, with 288 larvae, pupae, and adults, no weevils survived. In similar tests at a dosage of 15 ounces no weevils survived.

Owing to the difficulties involved in infesting draws and the time required in dissecting them, comparative studies were made of the effect of methyl bromide on imbedded eggs in sweetpotato roots. When imbedded in the roots, the eggs are protected by a mucilaginous cap, which should make complete mortality more difficult to obtain than in draws or vines, wherein this protective cap is not normally found. Approximately 1000 sweetpotatoes were fumigated. At a dosage of 15 ounces an estimated 56,857 eggs were destroyed and at 25 ounces an estimated 6693 eggs, fewer tests having been run at the latter dosage.

Adult weevils of both sexes were caged on vigorously growing draws on greenhouse benches so that infested plant material might be obtained for a study of the resistance of the imbedded stages to methyl bromide. Infestations were also obtained by mass liberation of the insects on caged seed beds. Two methods of study were used. In one method, the draws were permitted to grow until at least larval stages were present before fumigation, after which the treated draws with checks were dissected and the insects recovered. In the other method, the draws were fumigated a few days after being exposed to the weevils and were then planted with suitable checks. After several weeks they were dissected, and the potential insect population of the fumigated draws was calculated from the living specimens found in the checks. No draws were dissected until 6 days after fumigation.

Experiments on Plant Tolerance.—In determining plant tolerance to methyl bromide, draws and vine cuttings were fumigated and together with checks were planted in the field in 1939 at Sunset, and in 1940 and 1941 at Sunset and at Fairhope, Ala. The sweetpotatoes used at Sunset were mainly of the Porto Rico variety and at Fairhope were all of the Triumph variety. These two varieties predominate in the commercial sweetpotato-growing areas likely to be infested with the sweet-

Table 1.—Effect of methyl bromide fumigation before planting on draws of Triumph sweetpotatoes. Exposure period 4 hours. Temperature 80° F. Fairhope, Ala., 1940.

Date of Fumigation	Number of Plants		Per Cent Mortality of Plants		Yield in Bushels per Acre		U. S. Grade
	Fumigated	Check	Fumigated	Check	Fumigated	Check	
Dosage 25 ounces per 1000 cubic feet							
April 3	3636	5498	2.3	1.7	60	60	1
3	5392	5392	9.1	8.0	172	146	1 and 2
4	3990	3972	4.8	2.1	45	84	1
Average	—	—	5.8	4.6	—	—	—
Dosage 15 ounces per 1000 cubic feet							
4	3024	3140	1.1	1.3	72	72	1
4	3366	3480	2.5	1.7	112	112	1 and 2
Average	—	—	1.9	1.6	—	—	—

Table 2.—Effect of methyl bromide fumigation on draws and vine cuttings of Porto Rico sweetpotatoes. Exposure period 4 hours and temperature 80° F. Sunset, La., 1940.

Date of Fumigation	Type of Plants	Per Cent Mortality of Plants		Yield in Bushels per Acre				Per Cent Crown Infestation		Number of Infested Potatoes	
				U. S. 1		U. S. 2					
		Fumigated	Check	Fumigated	Check	Fumigated	Check	Fumigated	Check	Fumigated	Check
10 ounces per 100 cubic feet											
June 11	Draws	4.6	4.3	60	24	24	24	—	—	116	240
11	Draws	1.1	3.8	34	27	23	19	0	0	0	0
13	Vines	.8	1.0	48	48	24	24	0	1	0	0
19	Draws	10.2	1.9	21	30	24	30	0	0	0	0
21	Vines	3.7	5.7	96	114	36	42	0	0	0	0
28	Vines	0	0	48	53	21	24	1	0	41	48
July 3	Vines	.7	.6	60	60	30	30	0	0	0	0
Average		1.9	1.6	—	—	—	—	—	—	—	—
15 ounces per 1000 cubic feet											
Apr. 30	Draws	10.9	11.4	22	38	22	22	1	1	0	32
May 14	Draws	9.8	6.1	107	95	25	25	0	0	13	32
14	Draws	24.3	14.1	67	67	22	22	0	0	0	0
June 7	Vines	3.4	2.2	152	123	57	57	0	0	0	0
10	Vines	.8	1.0	165	188	32	44	1	2	0	57
10	Draws and vines	1.4	1.8	96	100	33	33	0	0	0	0
10	Draws and vines	2.0	1.5	120	92	14	10	0	1	0	0
10	Vines	.7	1.5	100	97	25	25	8	13	210	252
10	Vines	3.7	2.7	77	98	31	35	0	1	63	168
Average		6.0	5.3	—	—	—	—	—	—	—	—
25 ounces per 1000 cubic feet											
May 14	Draws	18.7	19.0	56	54	18	17	0	0	0	0

potato weevil. It was desired to find whether there are varietal differences in tolerance to the fumigant. Counts and inspections were made after a suitable period to determine the number of living plants and their condition.

On June 6, 1939, 6739 vine cuttings were fumigated at a dosage of 25 ounces for 4 hours at 80 to 83° F. and were set in the field at Sunset on the same day. Planting was begun in the check plot on June 5 and completed on June 7, about the same number of vine cuttings from the same bed being used. The plots were approximately three-fourths acre. A count made 16 days after planting showed a mortality of 7.2 per cent for the fumigated plants and 5.6 per

Table 3.—Effect of methyl bromide fumigation before planting on draws of Triumph sweetpotatoes. Dosage 16 ounces per 1,000 cubic feet for 4 hours. Temperature 80° F. Fairhope, Ala., 1941.

Date of Fumigation	Number of Plants		Per Cent Mortality of Plants	
	Fumigated	Check	Fumigated	Check
Apr. 9	3,300	3,318	1.4	1.1
9	2,460	2,220	3.0	2.7
10	3,130	3,390	4.8	5.7
11	3,232	3,232	1.1	1.8
11	1,415	1,425	0	0
Average	—	—	2.4	2.6

cent for the checks. A count was made of the infested potatoes in 12 rows in each plot as they were dug. A total of 132 potatoes were found to be infested in the fumigated plot and 263 in the check plot. The yield of U. S. Grade 1 potatoes from the fumigated plot was 35 crates and from the check plot 25 crates. The plants used in this test were grown on an infested farm. The fumigation killed the weevils in the plants set in the treated plot. Although these plants became reinfested after being set in the field, they showed a significant reduction in the number of infested potatoes.

In 1940 data on plant mortality and yield were obtained in 5 tests at Fairhope, and data on plant mortality, crown infestations, infested potatoes, and yield were obtained in 17 tests at Sunset, 7 of which were made at a dosage of 10 ounces, 9 at 15 ounces, and 1 at 25 ounces. In each test 1 acre was planted with fumigated draws or vine cuttings and 1 adjacent acre with untreated draws or vine cuttings from the same seed bed. A total of 19,408 draws were fumigated at Fairhope and 85,051 draws and vine cuttings at Sunset. The results are given in tables 1 and 2.

Counts of plant mortality, yield, and infested potatoes were made on one-third of the rows in each plot. The rows were selected at random. Mortality counts were made 15 days after the plants were set in the field, and the data on yield and infested potatoes were taken at harvest. Crown infestation was determined by making 10 inspections of 10 crowns each selected at random over each plot.

In 1941 data were obtained on plant mortality in 5 tests at Fairhope, using 13,537 fumigated draws and in 10 tests at Sunset using 53,014 fumigated draws and vine cuttings. In these tests it was not possible to use 1-acre plantings on all farms. Check plantings of the same size as those treated were used in all tests. The results are given in tables 3 and 4.

In addition, approximately 80,000 draws and vine cuttings were fumigated at Sunset in 1940 to furnish clean plants for 10 acres of commercial plantings. In 1941 approximately 1,500,000 draws and vine cuttings were fumigated in coopera-

Table 4.—Effect of methyl bromide fumigation on plants of Porto Rico sweetpotatoes. Dosage 16 ounces per 1,000 cubic feet for 4 hours at 80° F. Sunset, La., 1941.

Date of Fumigation	Per Cent Mortality		Yield in Bushels per Acre				Number of Infested Potatoes		Per Cent of Infested Crowns	
			U. S. No. 1		U. S. No. 2					
	Fumigated	Check	Fumigated	Check	Fumigated	Check	Fumigated	Check	Fumigated	Check
May 6	8.9	4.5	80	93	27	27	0	0	0	0
6	16.2	5.5	20	16	8	8	0	48	1	0
28	2.7	3.4	44	56	6	18	0	0	0	0
28	0	0	156	189	12	15	0	0	0	0
29	1.9	.4	156	156	36	36	90	120	0	1
29	0	0	108	108	54	54	400[1]	400[1]	0[2]	0[2]
29	.26	.15	160	160	32	32	0	0	0	0
June 30	9.2	6.0	77	84	30	30	18	136	3	4
July 2	3.7	2.8	120	160	16	21	0	0	0	0
May 29	4.9	.6	147	147	21	21	56	28	2	5
Total[3] or Average	5.16	2.86	1068	1169	242	262	—	—	—	—

[1] Fumigated plot adjoining mother beds, which were heavily infested.
[2] Harvested before crown count could be made.
[3] Total plants fumigated, 53,014; total check plants, 51,354.

tion with the Louisiana State Department of Agriculture and Immigration. No checks were used. Satisfactory stands and yields were obtained from these plantings of fumigated stock.

SUMMARY AND CONCLUSIONS.—Studies on the fumigation of sweetpotatoes with methyl bromide for control of the sweetpotato weevil were carried on at Sunset, La., and Fairhope, Ala., during the years 1938–41. In a series of 15 laboratory tests with 1122 infested plants, methyl bromide at the rate of 10 ounces per 1000 cubic feet for 4 hours at 80° F. gave a complete kill of all weevil stages. In 38 field tests with 177,749 draws and vine cuttings, dosages as high as 25 ounces per 1000 cubic feet for 4 hours at 80° or above caused no excessive mortality to the plants. From approximately 1,580,000 draws and vine cuttings fumigated and used for commercial plantings, satisfactory stands and yields were obtained.

It is evident, therefore, that a reasonably wide margin of safety exists between the dosage which will injure the plants and that required to destroy the sweetpotato weevil in the plants. A dosage of 16 ounces per 1000 cubic feet for 4 hours at 80° F. appears to be the most convenient schedule for commercial usage. —10-13-42.

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Laboratory Rearing of *Microbracon vestiticida* Vier. on the Bean Weevil, with Notes on the Life History of the Parasite

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In the fall if 1941 two shipments of adults of *Microbracon vestiticida* Vier., a parasite of the Peruvian cotton square weevil, *Anthonomus vestitus* Boh., were received from Peru at the foreign parasite introduction laboratory of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, at Hoboken, N. J. It had previously been established that *M. vestiticida* would attack the boll weevil, *A. grandis* Boh., and the parasites were sent to the laboratory for use in the development of methods of mass rearing for liberation against the boll weevil in the southern states. Large-scale rearing on the boll weevil is impracticable, since mature larvae and pupae are not available in the field during several months of the year. Laboratory production of the boll weevil is not feasible because of the need for growing cotton plants, in which the larvae develop. The experimental work described in this paper was designed to develop methods of rearing on some readily available host and was carried on from the fall of 1941 to the spring of 1942.

PRELIMINARY EXPERIMENTS.—It was hoped that the larvae of the Mediterranean flour moth, *Ephestia kuehniella* Zell., might serve as a host because of the ease with which they can be reared in the laboratory. The parasite, however, showed no interest in this insect, although it was presented under a variety of conditions. Eggs laid on other hosts were placed on coddled *Ephestia* larvae, but the young parasite larvae all died without feeding. Apparently the host integument could not be pierced by the larval mandibles. Similar experiments were carried on with larvae of the confused flour beetle, *Tribolium confusum* Duv., the rice weevil, *Sitophilus oryza* (L.), and the bean weevil, *Acanthoscelides obtectus* (Say), but the parasites were attracted to the last-named species only.

METHODS OF INDUCING PARASITE OVIPOSITION AND REARING CONDITIONS.—The bean weevil stages to which the parasites are attracted are the pupae, prepupae, and larvae, in that order of preference. Beans containing these host stages always show the characteristic "windows" made by the mature larvae just before pupation and can be easily distinguished from the other beans. The "window" is

that part of the bean skin directly over the host cell, or cocoon, and is made translucent by the eating away of the inner skin coating by the mature larva.

At first, when infested beans were presented to the *Microbracon* females, very few ovipositions were obtained. It was then found that the females needed some support to enable them to pierce the bean skin with their ovipositors. The beans were therefore wrapped individually in mosquito netting. Marrowfat beans were used in most of the rearing work, as they proved the most satisfactory.

Further experiments showed that infested skinned beans were much more attractive to the parasite than were unskinned beans. Before the skins were removed, the beans were soaked in water for about 15 minutes. It was difficult to reas weevils in the skinned beans, however, as the larvae usually left them before becoming mature. Skinned lima beans proved more satisfactory than skinned marrowfat beans, but the larval migration was the same if overcrowding took place, and this was difficult to control. The skinned beans required no covering with mosquito netting, but much labor was involved in skinning them. This was offset somewhat by the higher parasitization obtained. In the skinned beans the developmental period of the host was almost twice that in unskinned beans.

Cracked or split beans, with the skin still intact, were also infested. Fewer larvae left these beans, but in many instances the host cell was not formed close enough to the exposed half of the bean to attract the parasites. The host developed in the normal length of time.

Best results were obtained when unskinned beans were placed in bean-width sacks of mosquito netting about 4 inches long and twisted at the ends. The sacks were dipped in water and shaken out just before being placed in the oviposition cages. This caused the netting to be drawn tightly around the beans and the skins to become softened.

It was found that when bean weevil larvae or pupae were placed inside the ripe silk pod of the ordinary milkweed, close against the pod wall, the parasites would oviposit in them. The females had previously been observed to be strongly attracted to the milkweed pod and to probe it frequently with their ovipositors, even when no host material was inside. To permit the parasite female to reach the hosts with her ovipositor. the inner lining of the pod had to be removed. Many eggs were obtained from milkweed pods, but the procedure of removing and replacing these eggs on fresh hosts required much labor and the mortality was high because of handling. Eggs and, occasionally, newly hatched parasite larvae were removed from the pods and placed on host pupae in their cells in beans, after the windows were opened slightly.

Parasite eggs and larvae placed on hosts in artificial cells and gelatine capsules did not develop well, for the parasite larvae left the host and died or the host decayed. Material placed in natural weevil cells developed normally, and none of the larvae left, although all were exposed to the air.

Most of the parasite-rearing work was done at 70° F., as this temperature gave the most satisfactory results. At higher temperatures there was some mortality, especially among the parasites that were transferred to opened weevil cells in the beans. In such cases the host often died within a few days and then the parasite died. At 75° to 80° many more weevil larvae left the skinned beans than at 70°. Best results were obtained when the infested skinned beans were held at 80° until the host had transformed to the last instar and then transferred to 70°.

When the host pupa became brown before the parasite had completed its development, the latter could not pierce the hardened host skin and soon died. To remedy this condition, it was necessary to place the infested beans at 50° F. when the prepupal and white pupal stages were reached and hold them at that temperature for a week or two. Then, after the beans were removed to the 70° temperature, the parasite was able to mature before any appreciable development of the host took place.

REARING OF THE HOST.—To have adequate host material on hand at all times, it was first necessary to insure a dependable supply of bean weevil eggs. A 2-quart ice-cream container, the bottom lid of which was cut out and replaced by 18-mesh wire screen, was used for weevil oviposition. A few beans were placed in the container to encourage oviposition, and 10 to 20 thousand weevils were intro-

duced through a hole in the top. The eggs were caught in a petri dish, upon which the container rested. They were sifted each day and counted by means of a previously prepared measuring tube. This tube was made from a piece of a broken thermometer with the mercury removed. One end was plugged, and 1000 eggs (actual count) were placed inside. The tube was then tapped slightly to settle the eggs, and a mark was made at the final level of the eggs. About 500 beans were set aside in a glass dish, and 6000 eggs were dusted over them. From 4 to 10 weevils developed per bean, since the average hatch of eggs was about 80 per cent. If skinned beans were used, a ratio of 4 eggs per half bean was allowed, to prevent overcrowding. Unskinned beans were held at 80° F. until about 10 per cent of the windows had appeared, then at 60 for 2 days, and after that at 50°. Windows began to appear after about 3 weeks at 80°. By this method it was readily possible to hold the host in the proper instars for as long as 2 months without injury.

MATING OF THE PARASITE.—Mating was easily accomplished in wooden cages 4 by 6 by 5 inches, which were covered in the front with 30-mesh copper screen and had a sliding door at the back covered with the same screen and a 1-inch hole in the top for insertion of the parasites. In the earlier experiments strong muslin was used to cover both front and back, but the parasites usually cut their way through even on the side away from the light, and consequently copper screen was substituted throughout. Other small cages may be used satisfactorily for mating, as good results were obtained even with the oviposition cages described later. The adults were found to be positively phototropic to a high degree, and mating took place on the side of the cage facing the light. Mating occurred at 68° to 72° F., the optimum temperature being 70°. A concentrated solution of honey, powdered sugar, and water was sprayed on paraffined strips of paper and placed in the cages, along with a wet cotton plug. This food kept in good condition for a week or more.

Mating usually took place on the day of emergence. To insure proper fertilization, however, the females were removed from the emergence cages and placed with old males in the mating cages described above. The females were then removed about 1 day later and placed in the oviposition cages. Complete mating cannot be assured by this method, as some takes place in the emergence cages, and these females, of course, do not mate again when under observation in the mating cages. It was assumed, however, that most of the females were fertilized, as the percentage of females for the last complete generation was 44.7, a good figure for many braconids of this type.

PARASITE OVIPOSITION AND EMERGENCE.—The most satisfactory cages for oviposition were straight-sided glass dishes $7\frac{1}{4}$ inches in diameter and $3\frac{3}{8}$ inches high, with a cover of muslin tacked to a square wooden frame. The parasites could be tapped away from the cloth cover and the latter moved foward enough to leave an opening at the other side for adding parasites or removing objects from the cage. A pane of glass with a semicircular opening at one side was not satisfactory as a cover, as all the parasites could not be jarred from it, and when it was slid forward many parasites were caught and injured between the cover and the edge of the dish.

Since the relative humidity of the cage should be between 80 and 90 per cent, a large wet cotton pad 6 inches in diameter was kept constantly over one-third of the cover. A wet cotton plug about 2 inches in diameter was also placed inside the cage to meet the water requirements of the parasite as well as for additional humidity. Food was the same as used in the mating cages.

About 60 females 1 week old were placed in each cage. Females less than a week old were not in condition to oviposit and were held in similar cages without host material. Usually the females began ovipositing 10 days to 2 weeks after emergence, although a few seemed ready after about a week. A few infested skinned beans were placed in the cage after the first week, and, when the females were about 2 weeks old and laying well, 30 infested beans in sacks (about 4 hosts per bean) and 15 infested skinned beans were placed in each cage. The beans were removed after 2 or 3 days and replaced with fresh material, since the average female deposits only 1 egg each 2 days. The host material was always placed at the

side of the cage facing the light and that side was covered with dark paper. This inhibits excessive activity of the adults at the side of the cage. The most satisfactory temperature for oviposition is 70° F.

After removal from the oviposition cages, the parasitized host material was held in glass dishes with cloth covers at 70° F. It was found that this material could be safely reared at 80° if first held at 70° for 2 to 3 days immediately following parasitization. This shortened the developmental period of the parasite by a few days.

The collection of the adult parasites from the rearing cages was done by suction created by a central vacuum tank. The amount of suction was regulated by a special valve in the collecting-tube holder, and injury to the parasites was therefore prevented. The parasites are sucked through a small glass tube three-sixteenths inch in diameter inserted in a cork stopper that fits one end of a glass collecting tube. The opposite end of the tube was closed with muslin.

The last complete generation in the experimental series yielded 9.6 progeny per female for the 100 females that were used. The rearing of a generation from that number of females, from the time the first egg was deposited to the time of emergence of the last adult, covered approximately 3½ months at 70° F.

HABITS OF PARASITE.—Since nothing has been published on the life history of *Microbracon vestiticida*, it seems advisable to mention briefly some of the more important points in its biology. The host is only occasionally paralyzed, or stung, by the female. The egg is deposited externally upon its body and hatches in about 24 hours at 70° F. The newly hatched larva first crawls about over the host, apparently with the object of destroying any other eggs or larvae that may be present, as only one parasite can develop to maturity on each host. It usually feeds on the ventral side of ths host, at least after the first stage. When the host is not paralyzed, it is usually killed by the first instar after about 1 day of feeding. The larval stage covers 4 to 5 days and the period from egg to adult about 2 weeks at 70° F. The female sometimes feeds on the body fluids of the host, and to accomplish this she first paralyzes the host by stinging it with her ovipositor and then forms a feeding tube extending from the puncture in its body through the bean skin to the outside.

The females live from 5 to 6 weeks in the laboratory at temperatures of 70° to 75° F. The daily egg capacity, like that of many other braconids, appears to be rather low. Dissections of many females over a long period showed an average of only three fully developed eggs per female and a maximum of five.

SUMMARY.—*Microbracon vestiticida*, Vier. is a parasite of the Peruvian cotton square weevil, *Anthonomus vestitus* Boh., and was first imported into the United States in the fall of 1941. After evidence had been obtained that it would attack the boll weevil, *A. grandis* Boh., in the Southern States, experiments were conducted to find a method of rearing the parasite in considerable numbers in the laboratory.

Ephestia kuehniella Zell. and some coleopterous grain pests were tried as hosts, but the only insect that attracted the parasite was the bean weevil, *Acanthoscelides obtectus* (Say). Infested beans in mosquito-netting tubes or sacks were the most satisfactory for oviposition.

The egg is deposited externally on the host. The first larva that hatches kills all eggs and larvae that hatch later. Only a few hosts are paralyzed, or stung, by the female. The nonparalyzed host is killed by the young larva in a day or two. A feeding tube is formed extending from the host to the bean skin.

The last complete generation in the experimental series yielded 9.6 progeny per female for the 100 females that were used. By the use of the bean weevil as an alternate host, it is possible to build up the parasite stock during the winter, when immature stages of the boll weevil are not available, so that large releases can be made as soon as the proper stages of the weevil occur in the field in early summer.—9-14-42.

New Recommendations for Large Scale Control of the Sheep Tick in the Northeast[1,2]

H. H. Schwardt and J. G. Matthysse
Cornell University, Ithaca, New York

Control of the sheep "tick," *Melophagus ovinus*, is an annual problem in New York farm flocks. Demands for higher production of wool and mutton have brought the importance of this pest to the attention of all sheep raisers. It is expected that many more than the usual 10 per cent of New York's sheep will be dipped each season during the next few years. This and the fact that some of the previously used dips either were not entirely satisfactory, or were in danger of becoming unavailable led to the work reported upon in this paper.

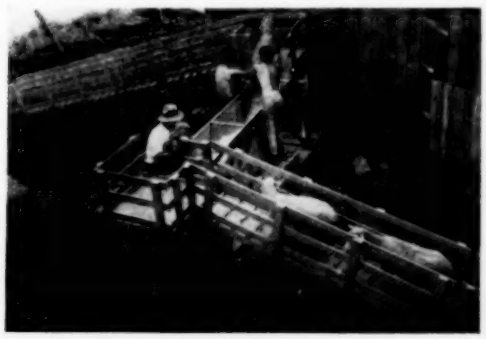


Fig. 1.—Portable sheep dipping vat in use.

New York farm flocks contain from a dozen to several hundred ewes, the average being around 50. Some of the larger flocks are provided with permanent dipping vats, but a considerable majority of all flocks treated are dipped in portable vats owned by the county farm bureaus. Some of these vats serve several counties and one of them handles from 20 to 30 thousand sheep annually at a cost of about 8 cents a head.

The vat used in these studies was typical of those operated by the county rings. It consists essentially of a galvanized iron tank of the usual shape fastened to a low two-wheeled trailer and provided with folding ramps and platforms for getting the sheep in and out of the vat (Figures 1, 2, 3, and 4). Exclusive of labor such a vat could be built for about a hundred dollars, at prices prevailing in 1941. The vat weighs 1500 pounds when empty and can be pulled easily by a small truck or passenger car. If steep hills must be negotiated, or if the vat is to travel partly filled, a heavier truck or small tractor is desirable as the motive power. A tractor is particularly useful when the outfit must be maneuvered into muddy barnyards.

An effort was made to secure heavily infested flocks, and to give them uniform treatment at the vat. All flocks used were examined a few days before dipping and again just before going through the vat to make sure that an infestation sufficient for fairly accurate counts existed. The sheep were driven into the barn only a short time before dipping, since most flocks had to be driven very short distances and no extended cooling-off period was required. The vat was then moved into position so that the approach ramp would just reach to the exit door of the barn. Inside the door a v-shaped forcing chute leading into the ramp was improvised from gates or boards. A crew of five men is desirable for running the sheep through the vat. Two of these work in the barn forcing the animals

Fig. 2.—Portable sheep dipping vat packed and ready for the road.

[1] This is a report on an investigation carried on by the Department of Entomology of the N. Y. State College of Agriculture under a fellowship provided by the Agricultural Department of the Texas Gulf Sulfur Company, Houston, Texas.

[2] Early publication of this paper has been secured by payment of the costs of printing.

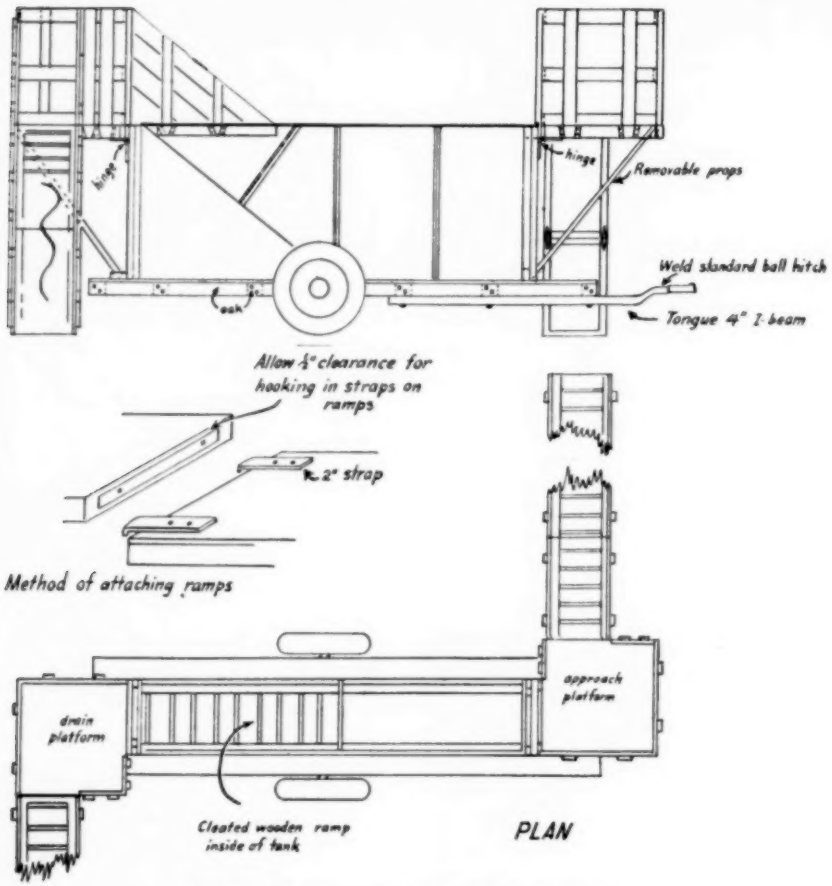


FIG. 3.—Plan for portable sheep dipping vat.

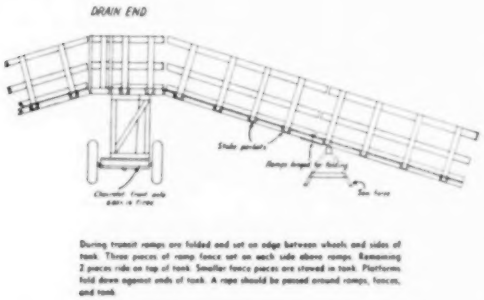
into the approach ramp, two work at the tank, and one acts as a rover to assist nervous animals up and down the ramps. Usually only two or three men travel with the vat, the remaining men being furnished by the flock owners. As each sheep reaches the approach platform it is turned about and pulled into the tank backward. This procedure makes it much easier to get the sheep completely under the surface especially when the tank is only partly filled. The animals usually right themselves and leave the tank unassisted but they must be closely watched and help given to any that do not get to their feet immediately. Each individual is kept in the dip an average of about 20 seconds.

In spite of all precautions, occasional sheep may jump the ramp or in some other way escape before going through the vat. Unless a good sheep dog is available it unually requires the work of the entire crew to round up such animals. Much time is lost and the escaped animal usually reaches the tank in a heated and exhausted condition. One sheep left undipped will of course make the experimental results for the flock questionable and will reinfest the flock. Because of this hazard it is highly desirable to do the dipping in fenced barnyards so that escaped animals can easily be recaptured. When the barnyard is not fenced a temporary enclosure around the vat should be arranged if at all possible.

While a large number of dipping formulae have been used, only three have given sufficient promise to justify large scale tests. These are as follows:

(1) Cube (5% rotenone)	10 pounds
Wettable sulphur	100 pounds
Water	1,000 gallons
(2) Fixed nicotine (*Black Leaf 155*)	10 pounds
Wettable sulphur	100 pounds
Water	1,000 gallons
(3) Wettable sulphur	100 pounds
Water	1,000 gallons

In preparing any of these formulae the dry ingredients are weighed into tubs and made into a thin paste with a small amount of water. The paste is then added to the tank slowly and the whole well mixed by repeatedly sinking and pulling up a twelve quart bucket in the vat. The sheep are started through immediately to insure continuous agitation of the dip. If the mixture stands for more than a few minutes without agitation some of the sulphur settles and must be brought back into suspension by stirring with a hoe or a flat board.



During transit ramps are folded and set on edge between wheels and sides of tank. Three pieces of ramp fence set on each side above ramps. Remaining 2 pieces ride on top of tank. Smaller fence pieces are stowed in tank. Platforms fold down against ends of tank. A rope should be passed around ramps, fences, and tank.

FIG. 4.—Portable sheep dipping vat. End view.

The rotenone-sulphur dip has been tested experimentally on approximately 2000 sheep representing a number of farm flocks and all the common breeds. In addition three county rings have used this formula on approximately 10,000 head. The result has been eradication of the "tick" in all flocks dipped. The biting sheep louse, *Trichodectes ovis*, was also eradicated when present. Only one dipping was necessary, and this usually occurred shortly after shearing. While this dip does not kill the pupae it remains effective long enough to kill all young "ticks" hatching from the pupae which were present at the time of dipping.

Wettable sulphur alone used at the rate of 100 pounds to 1000 gallons of water will usually eradicate the sheep "tick" but there are several objections to it. Eradication of an infestation usually is not complete until 6 weeks to 2 months after dipping with this mixture. Sheep growers are not satisfied with a dip which does not give a thorough kill within a few days. If during the 2-month period following dipping new sheep are brought into the flock, or if late lambs arrive there is a chance they will become infested and later, after the effectiveness of the dip has worn off, reinfest the entire flock.

Several hundred sheep were dipped in the fixed nicotine-sulphur mixture which contained 10 pounds of *Black Leaf 155* and 100 pounds of wettable sulphur in a thousand gallons. Complete control resulted in most of the flocks treated but there was one conspicuous failure. *Black Leaf 40* used at the same nicotine concentration gave incomplete kills in most of the flocks treated. Analyses for nicotine remaining in the wool of dipped sheep indicated that *Black Leaf 40* left only about half as much nicotine in the wool as did *Black Leaf 155* and this proportion obtained as long as a month after dipping. This difference may be due to the solubility of the nicotine sulphate which would allow it to drain off in part after the sheep leave the vat, while the insoluble fixed nicotine would be filtered out and retained on the wool. The one flock in which fixed nicotine failed to give control was dipped in a permanent concrete vat with a very efficient drain platform. Most of the drainings were returned to the vat. It is probable that in this instance the dip became progressively weaker in nicotine as the sheep passed through. It was also noted that control was better on the first sheep going through the tank than on the last few sheep in the flock. Control with fixed nicotine was consistently good when the portable vat was used, probably because more of the drain from the sheep was lost and the dip was frequently replenished with fresh material. The difficulty encountered with the permanent vat possibly could be surmounted by using a larger dosage of nicotine.

Sheep dipped soon after shearing require about a gallon of dip per head while those with late summer or early fall fleeces may require 2 gallons. At the rate of 1 gallon per head the rotenone-sulphur and nicotine-sulphur dips cost about a cent per head for materials, while the wettable sulphur alone costs 0.6 cents per head.

An Apparatus for Testing Chemotropic Responses of Flying Insects[1,2]

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Hoskins & Craig (1934) pointed out some obvious faults with numerous methods of testing insect response to odors and suggested several requirements of an ideal olfactometer. These requirements would also hold for any apparatus designed for testing response of organisms to any given environmental condition. Any apparatus can only approach the ideal because factors considered in design remain for the most part static while response of the organisms depends to a great extent on physiological state, which in itself is a tremendous variable.

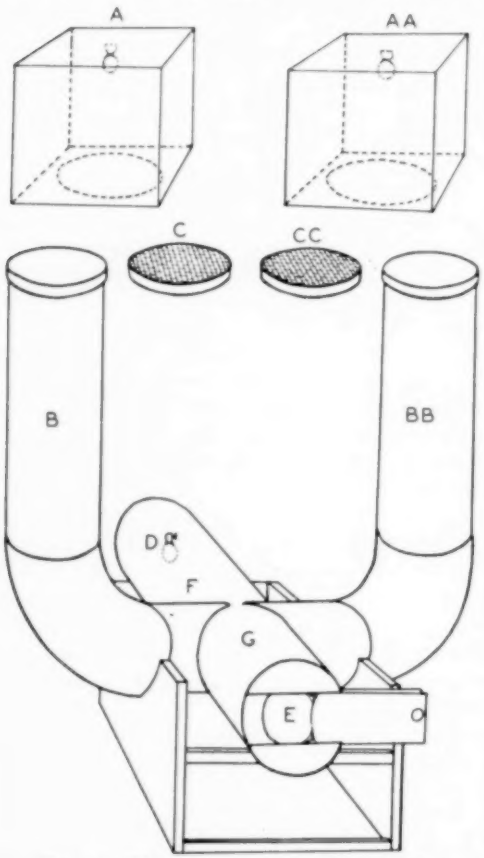

FIG. 1.—Diagram of apparatus described.

In the author's estimation, Kilgore (1939), with his "Sandwich Bait Method" has not adequately considered physiological variables. Flies coming to rest first on the 10 per cent citronellol strip and feeding will probably not react the same as flies which have never come in contact with the citronellol or which have taken food. It would seem that the results include the effects of citronellol plus or minus those of the sample (in the reported case, oil of pennyroyal), depending on whether the sample was an attractant or a repellent.

A substance which is repellent to houseflies depends for its action on stimuli of numerous receptors. Olfactory and tactile are probably the two most important senses associated with chemotropic behavior although their relative importance is not clear. Many of the devices designed for testing response to chemicals consider only olfactory or only tactile responses, but unless both factors are considered in a single test, a true picture of the test material is not revealed. With any apparatus, results should be checked in so far as possible, with practical tests.

APPARATUS.—The apparatus reported in this paper is simple in construction and, according to results obtained, accurate in giving a fair picture of the repellent or attractant properties of various materials, whether they be water or oil soluble. It cannot, strictly speaking, be termed an olfactometer or a tactometer but possibly a chemotropometer. Its use thus far has been confined to houseflies and stableflies but undoubtedly other flying insects could be used.

The reactance chambers (Fig. 1) *B*, *BB*, *F* and *G* were all constructed from ordinary 6-inch stove pipe, the interior of which was painted a very dull black to reduce light reflection. The distance between *B* and *BB* is 16 inches and that from the top of the arm to its cradle rest is 24 inches. Felt weather strip was fastened around the outside at the top of each arm so that the two screens, *C* and *CC* would fit snugly over each arm. A 15-watt bulb is located in each of the light boxes *A* and *AA* so that the light is di-

[1] These studies have been supported by Velsicol Corporation, Chicago, Illinois.
[2] Early publication of this paper has been secured by payment of the costs of publication.

rected through a glass plate covered with thin tissue paper and blue cellophane onto screens and down the arms. Each light is equally distant from the screens and the light intensities are the same. Flies are drawn into the chamber at *E* by a light turned on at *D*. A screen separates arm *F* from the main chamber. Light *D* is then turned off and lights *A* and *AA* turned on. Thus the flies are attracted to the two screens *C* and *CC* which are in place on each arm. A fan in arm *F* just distad to light *D* pulls a very gentle stream of air down the two arms *B* and *BB* and out. Thus, odors in one arm do not enter the other. Measurements in construction should be accurate so that the finished apparatus is as nearly bilaterally symmetrical as possible.

Approximately 30 flies are introduced into the chamber for each test. Repeated introductions proved that the flies reacted positively to the blue light and came to rest on the screens. However, they do go back and forth from one screen to the other, indicating that there is no light block near the screens and also that the test organisms have more than one opportunity to make a choice of screens. Very few flies remain on the walls of the arms. Eagleson (1939) used light from an ordinary bulb diffused by thin white paper to attract test organisms but tests in our laboratory showed that more flies came to rest on the screens when blue light was used. Eagleson's olfactometer employs untreated screens but these are inserted into the arms and the flies must be counted by using a mirror.

Numerous tests in which both screens were untreated proved that the apparatus was so constructed that approximately 50 per cent of the flies would go to one screen and 50 per cent to the other. The actual result was 50.01 ± 0.64 per cent.

METHOD OF OPERATION.—An experimental test involves the spraying of one screen with the test substance and allowing the other screen to remain neutral or to be sprayed with the test material solvent. The spraying was done by the introduction of six-tenths of one cubic centimeter of test substance into an atomizer which would discharge it in seven seconds through a two-foot horizontal length of six-inch stove pipe and onto the screen *C* or *CC* placed over the other end of the pipe. Thus, the mist was blown through the screen and repeated tests gave a consistency of results which indicated that the dosages were quite constant. With the screens in place on the two arms, flies were admitted and allowed 15 seconds to make a choice of screens. Ten counts at 10-second intervals were made alternately on each screen and the results summated. Numerous variations of the above procedure were tried to determine accuracy and consistency. First, one screen would be treated and tested, then the other, or a screen would be tested on one arm and then on the other. None of these variations interfered with or altered the results. Below, in table 1, are shown the results of tests on two different substances and the method of calculation.

Table 1.—Chemotropic tests of paraffin oil and diphenyl ether on flies.

NUMBER OF FLIES ON SCREENS AT EACH COUNT			
Paraffin oil		Diphenyl ether	
N	T	N	T
12	12	15	4
14	13	12	6
13	13	13	4
12	13	16	3
14	14	17	4
15	14	14	4
15	14	15	3
13	15	14	5
12	12	14	4
14	12	12	4
134	132	142	41
266		183	
E = −.8		E = −55	

Since 50 per cent of the flies would be on each screen if each were neutral, the actual percentage of flies repelled from or attracted to the treated screen would then be

$$2\left(\frac{100\times T}{(T+N)}-50\right)=E.$$

T = flies on treated screen
N = flies on neutral screen
A minus value for *E* indicates repellency and a plus value attractiveness.

Paraffin oil, which theoretically should be neutral shows an *E* value of −.8 which is practically the same as that of a neutral screen. Undiluted diphenyl ether results in an *E* value of −55 which indicates that as used, it has repellent properties.

In addition to checking quickly and accurately the initial response of flies to a test substance, the time range over which the substance will evoke a response can be determined. In most of our tests, flies were removed from the chamber immediately after a test and fresh flies introduced at 15-minute intervals until the effect of test materials was no longer apparent. Numerous spray formulations and pure substances have been tested with the apparatus and the results showed consistency when compared with those obtained in field tests.

The apparatus is also useful for testing the response to odors. A piece of screen, 6 inches in diameter is sprayed and laid over the neutral screen on one arm. The flies coming to rest on the underneath screen do not actually come in contact with the spray material but are so close to it that they are subjected to the full strength of the odor. Work of a preliminary nature indicates that tactile stimulation is extremely important as a property of repellents.

SUMMARY.—An apparatus is reported which employs the use of blue light to attract house or stableflies to screens for the purpose of testing their response to different substances present on one of the screens. Subjection of flies directly to the test materials present in the state in which they would be used in field tests evokes response which represents a summation of the organism's receptor system. The apparatus is simple in construction, easily used and gives a fair picture of the effectiveness of any given material as a repellent or an attractant. Response to odors can also be tested with the apparatus.—1-30-43.

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SCIENTIFIC NOTES

Toxicity of Some Nitroparaffins to the Confused Flour Beetle

HENRY H. RICHARDSON, MILTON S. SCHECHTER, and H. L. HALLER, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The development by Hass *et al.* (1936) of an efficient method of nitrating the gaseous paraffins has made available commercially and at a low cost a number of homologous alkyl nitro compounds, or nitroparaffins. While numerous studies have been published on the insecticidal properties of aryl nitro derivatives, nitromethane and nitroethane only, of the nitro alkyls, have apparently been evaluated for their toxicity to insects. Roark & Cotton (1930) found nitroethane to be more toxic than nitromethane as a fumigant to the rice weevil, and McAllister & Van Leeuwen (1930) found nitromethane to be 52 per cent as efficient as lead arsenate against the codling moth larva.

It appeared of interest to determine the insecticidal value of the readily available homologs of nitromethane, and in this paper are given the results of toxicity tests conducted in 1939 and 1941 on six nitroparaffins as fumigants against the confused flour beetle, *Tribolium confusum* Duv. The compounds were tested in 5- or 6-liter glass flasks by the method described by Richardson & Casanges (1942). Five-hour exposures at 25° C. and approximately 50 per cent relative humidity were used. The compounds were tested 12 to 14 times at various concentrations near the minimum lethal concentration. From 50 to 100 beetles were used per test, and the final mortality counts were made 10 to 20 days after the treatment.

The approximate concentrations to kill 50 and 95 per cent of the insects were determined from free-hand curves drawn on logarithmic probability paper. Table 1 summarizes the results.

Table 1.—Toxicity of six nitroparaffins and carbon disulfide as fumigants against the confused flour beetle after exposure for 5 hours at 25° C.

Chemical	Approximate Concentration to Give—	
	50 per cent mortality	95 per cent mortality
	Mg. per liter	*Mg. per liter*
1-Nitrobutane ($CH_3NO_2CH_2CH_2CH_3$)	8	10
Nitroethane ($CH_3NO_2CH_3$)	9	14
1-Nitropropane ($CH_3NO_2CH_2CH_3$)	11	16
2-Nitrobutane ($CH_3CHNO_2CH_2CH_3$)	13	20
2-Nitropropane ($CH_3CHNO_2CH_3$)	19	35
Nitromethane (CH_3NO_2)	37	55
Carbon disulfide (CS_2)	56	100

All the nitroparaffins were much more toxic than carbon disulfide. 1-nitrobutane appeared to be almost as toxic as methyl bromide (Richardson & Casanges 1942), but it is much less volatile. In compounds having the nitro group attached to the first carbon atom, toxicity increased from nitromethane up to 1-nitrobutane, except for nitroethane, which was slightly more toxic than 1-nitropropane. Substitution of the nitro group into the 2 rather than the 1 position reduced toxicity definitely in the propane and butane compounds tested. The compounds containing the nitro group in the 2 positions, however, have an advantage in being more volatile. Nitromethane was much less toxic than nitroethane, in direct contrast to the relative toxicity of methyl and ethyl bromides to this beetle (Richardson & Casanges 1942). Studies of a possible postfumigation effect showed little change in mortality of fumigated beetles from the 4th to the 20th day.

The nitroparaffins are low in cost, have a mild odor, and are fairly stable, and the vapors of nitropropane are less toxic to rats and guinea pigs than are those of carbon disulfide or carbon tetrachloride (Hass *et al.* 1936). A more detailed pharmacological study of the nitroparaffins has been reported by Machle *et al.* (1940). The solubilities in water of nitromethane, nitroethane, and 1-nitropropane are about 10, 5, and 1.5 per cent, respectively, at 20° C. The flash point (Tag open-cup) of nitromethane is 112° F., that of nitroethane 106° F., and that of 1-nitropropane 120° F. The vapor pressure of nitromethane at 20° C. is 27.6 mm. (Hodge 1940), which is close to that of chloropicrin (29.7 mm.). At the same temperature nitroethane has a vapor pressure of 16 mm., and this value is progressively lower as the homologous series is ascended.

These nitroparaffins have been shown to be useful in the production of pharmaceuticals, dyestuffs, rubber chemicals, resins, and other materials, and apparently there is a large potential supply. They appear worth further study as fumigants or contact insecticides.—12-2-42.

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Volatile Fluorine Compounds as Insecticides

R. C. ROARK, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Marcovitch (1942) recently called attention to the use of volatile fluorine compounds for the control of insects. He reported that hydrofluoric acid, silicon, tetrafluoride, hydrofluosilicic acid, and boron tri-

fluoride, when tested as fumigants, were highly toxic to cowpea weevils, grain weevils, bean weevils, bedbugs, roaches, and other insects.

It is well recognized that fluorine compounds are toxic to man. Fluorine residues on apples resulting from the application of sprays containing cryolite (sodium fluoaluminate) are regarded by publichealth officials as deleterious to health if the quantity exceeds the equivalent of 0.02 grain of fluorine per pound. This is equivalent to 2.8 parts per million. The compounds mentioned by Marcovitch, however, have physical and chemical properties and toxic action on man which preclude their practical use as insecticides.

Hydrofluoric acid is highly corrosive. It readily attacks metals and is used commercially for etching glass. For use in the chemical laboratory its aqueous solution must be kept in a paraffin bottle. In contact with the skin hydrofluoric acid causes deep, painful burns, which heal slowly. Continued exposure to even a low concentration of hydrofluoric acid vapor gives rise to chronic bronchitis. The teeth are attacked and the necrosis may spread to the jaw. Fumigation with hydrofluoric acid at the minimum dosage necessary to kill weevils in grain would leave a fluorine residue on the grain much greater than that permitted on sprayed fruit. As long as fumigants that leave little or no poisonous residue on commodities exposed to their vapors are available, there seems to be no good reason for turning to a chemical that corrodes metals, etches glass, poisons food, and burns the operator.

Silicon tetrafluoride on contact with water is converted into hydrofluosilicic acid. It could be used as a fumigant only under anhydrous conditions, in which case the insects would perish anyway for lack of moisture.

Hydrofluosilicic acid is not sufficiently volatile to serve as a fumigant.

Boron trifluoride in contact with water forms fluoboric acid and, like silicon tetrafluoride, could be applied only in the absence of moisture.

Among other voltatile inorganic fluorine compounds that might be even more toxic to insects than hydrofluoric acid, silicon tetrafluoride, or boron trifluoride may be mentioned arsenic trifluoride, antimony trifluoride, sulfur tetrafluoride, sulfur hexafluoride, selenium hexafluoride, tellurium hexafluoride, and osmium octafluoride. All of these are too poisonous to man to be recommended as practical fumigants; moreover, residues on foodstuffs of compounds of antimony, arsenic, selenium, tellurium, or osmium would be highly objectionable, and some of them very dangerous.

Certain volatile fluorine compounds that are toxic to insects may prove to be practical fumigants, but the writer believes that these compounds will be organic, not inorganic. An example is fluoroform, patented for use as a clothes moth fumigant by the I. G. Farbenindustrie (1930). The esters of fluoroacetic acid might also prove effective and are worthy of testing.

Marcovitch (1942) attributes to the writer the finding that dichlorodifluoromethane with pyrethrins and sesame oil is a good fumigant for the control of houseflies. He is referring to the aerosol method of distributing insecticides developed by Goodhue and Sullivan (1942). As used by them the dichlorodifluoromethane contributes nothing to the kill; it serves only as a solvent and as a propellent for ejecting the active principles from the container. —11-23-42.

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A Combination of 2,4-dinitro-6-cyclohexylphenol with Sulfur as a Substitute for Pyrethrum for Control of Potato Leafhopper

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For many years bordeaux mixture was considered a standard control for the potato leafhopper *Empoasca fabae*, particularly on potato. As the same insect became a more serious pest of beans in many areas, especially in Florida and Texas during certain seasons, and began to cause a severe yellowing condition and damage to alfalfa, insecticides suitable for dust applications were needed.

At that time DeLong & Howard (1934) and DeLong (1934) carried out a large number of experiments using a number of different materials including a series of sulfur compounds and plant insecticides. They found that rotenone dusts did not give satisfactory control of the leafhopper whereas pyrethrum proved to be an excellent toxic agent. However, pyrethrum-sulfur mixtures gave better field control than did the pyrethrum alone. The pyrethrum afforded a high initial kill of the leafhoppers but was effective for only a few hours, while the effectiveness of sulfur persisted, producing a marked mortality upon the young nymphs as they hatched.

Possible shortage of pyrethrum as an agricultural insecticide and the introduction and extensive use of insoluble copper sprays as potato fungicides and their failure to control the leafhopper have served as incentives for the development of an effective dust which will control leafhoppers and at the same time act as a fungicide. Consequently laboratory and large scale field experiments have been carried on during the past two years in an attempt to find a suitable substitute for pyrethrum in dust mixtures.

Sulfur has been used effectively as a fungicide for many years, and as its toxic properties as an insecticide continue to be effective over a comparatively long period of time, it was used as the base for the dust mixture. Boyce *et al.* (1939) reported satisfactory control of the citrus red mite, *Paratetranychus citri* McG. and the common red spider *Tetranychus telarius* (L) using a dust mixture composed of 1 per cent DN[1] incorporated with walnut shell flour. Kagy and McCall (1941) found that the dicyclohexylamine salt of 2,4-dinitro-6-cyclohexylphenol was toxic to many species of mites and certain species of thrips when applied as a dust containing 1 per cent DN by weight. Therefore, a series of DN-sulfur and the dicyclohexylamine salt of DN-sulfur dusts were prepared and extensively tested on beans,

[1] 2,4-dinitro-6-cyclohexylphenol.

potatoes and alfalfa.

Dusts containing either DN or the dicyclohexylamine salt of DN incorporated with sulfur and an inert diluent were prepared by the "solvent mix" method (Boyce *et al.* 1939). The first dust contained 1 per cent DN, 50 per cent sulfur and 49 per cent of an inert diluent (volcanic ash). The second dust contained the same quantity of DN and sulfur but in addition is contained dicyclohexylamine equivalent to the DN present and the remainder was again composed of the inert diluent. Dosages used on the different crops ranged from 20–45 pounds per acre.

A preliminary report of both the laboratory and field experiments was given at the annual meeting of the American Association of Economic Entomologists in 1941. At that time it was felt that DN-sulfur combinations offered a great deal of promise as a control measure for *Empoasca fabae*. Further extensive laboratory and field experiments appear to have justified that belief. Both the DN-sulfur dust and a dust composed of the salt of DN plus sulfur have been used with satisfactory results. The excellent foliage color, absence of yellowing and leafhopper "burn," the marked reduction in population counts on alfalfa, potato and beans and the increased flowering of alfalfa indicate that these dusts give an excellent control of the potato leafhopper. Furthermore, no injury to the foliage of potato, bean or alfalfa has been noted during the past two years. It is, therefore, felt that DN-sulfur combinations can safely be recommended for the control of the leafhopper on these crops.—9-20-42.

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A White Grub Injuring Peanuts in Eastern Virginia

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A previously undescribed type of damage to peanut pods caused by a white grub was observed during the course of a 4-year study on peanut leafspot control in Eastern Virginia. This damage was first noticed in September 1938 at Holland in Nansemond County, Virginia. At that time, however, the causal agent was not found; therefore, it was impossible to determine the cause of the injury. Severely damaged pods had one to three almost perfectly round holes of from 0.5 to 1 centimeter in diameter cut in the sides of the pericarp (Fig. 1, A). There were no whole kernels in these pods, but the presence of debris of broken down kernels showed that ovules had been formed. The shell of pods less severely damaged was not completely penetrated, but showed honeycombed lesions on the surface. The veins of the mesocarp in the lesions were intact but the endocarp of the pod was exposed (Fig. 1, B). The kernels in these pods were found to be in good condition except in cases where decomposition had occurred as a result of soil fungi (*Rhizoctonia* spp.) penetrating the weakened mesocarp wall. Losses from such injury, however, are great even though the kernels are uninjured, because all pods with damaged shells are saleable only as shelling stock.

On October 10, 1939, 25 representative plants in 7 different fields in Nansemond County were dug to determine whether damaged pods with injury similar to that observed in 1938 were present. Pods thus damaged were found in 4 of the 7 fields, but in only 2 of the fields was the injury generally distributed and severe. White grubs, identified by T. N. Dobbins as larvae of *Strigoderma arboricola* Fab. (Fig. 1, C) were found in some of the pods, but it was impossible to tell whether the grubs had eaten the holes in the pods or had merely entered as secondary agents.

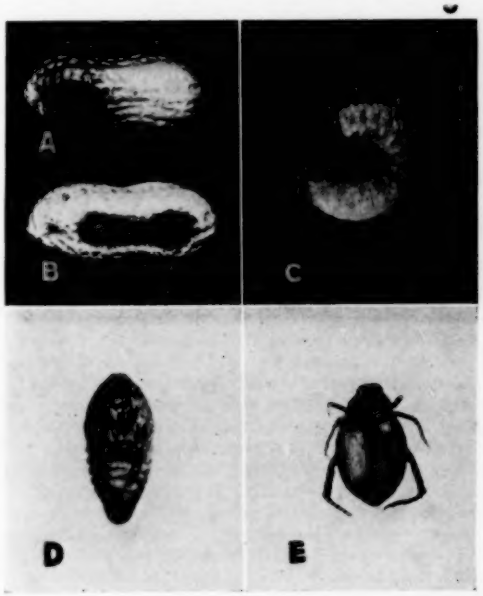

FIG. 1.—A and B. Damage to peanut pods caused by white grubs. C–E. Larva, pupa, adult, respectively, of *Strigoderma arboricola* Fab.

While peanuts were being dug in the fall of 1940, it was observed that white grubs had cut the holes in the pods and also had caused the honeycombed lesions on the pericarp wall. In one field as many as 35 grubs were found under a single hill of peanuts. Many of this number were feeding on the pods, others were feeding on the pegs and rootlets, and still others were only resting in the soil, 6 to 7 inches below the level of the crown of the plant. Grubs feeding on mature thick-shelled pods were only able to eat out the intercostal tissue down to the endocarp, thus causing the honeycombed lesion type of injury (Fig. 1, B); whereas those feeding on immature or thin shelled pods were able to eat through the wall of the shell and consume the kernels (Fig. 1, A). It was discovered that many of the so-called "blank" plants (large, viney plants with many blossoms but

no pods) were simply plants which had been stripped by white grubs of all underground parts except the main root. It was observed that peanuts growing in dark soil types, high in organic matter, where the plants had made heavy vine growth, were more commonly affected by the grub than were those growing in the light soil types with less organic matter and which had made poor vine growth. The number of grubs, as well as the amount of injury caused by them, was also found to be greater in the low spots in fields and in the water furrows.

White grub specimens collected in the fall of 1941 from soil under plants which had been injured by white grubs were identified by P. O. Ritcher as the larva of *Strigoderma arboricola* Fab. Grub specimens from the same lot sent to Ritcher were reared by C. B. Dominick to adults (Fig. 1, D). Specimens of the adult beetles were determined by J. McD. Grayson to be *S. arboricola*.

Adults of *Strigoderma* are quite common in eastern Virginia from about May 15 to June 10 (Fig. 1, E). During this period they may be found in the blossoms of roses where they cause great damage. Because of their manner of feeding between the petals of the rose blossoms, it is impossible to get over 10 to 15 per cent control of this beetle with any proprietary insecticide. Gardeners commonly call the insect the "spring rose bug." This beetle also attacks other ornamentals that may be in bloom at the time, but it causes its greatest damage to rose flowers. The beetle is also quite common on the foliage and blossoms of peanuts at this time. In some fields it is not uncommon to find as many as 30 beetles walking over or flying around a single hill of peanuts. The beetles are weak flyers and in flight act as though they are intoxicated. Observations have only been made in peanut fields within a 10-mile radius of Holland, Virginia, but during the period of maximum emergence beetles have been found in every field visited.

Although 90 per cent of all the peanuts grown in Virginia are raised in 7 eastern counties, a survey to determine the degree and extent of damage by white grubs to peanuts has not been made. However, injury to pods caused by white grubs has been found in each of these 7 counties. Apparently, though, the greatest damage is incurred by the grub in the southern part of the belt from the North Carolina border line north to Suffolk on the east and to Emporia on the west. In Virginia the southern corn rootworm causes greater total damage than any other underground pest, although the injury rarely exceeds 25 per cent total loss of saleable nuts in any one field. The white grub may cause a loss of 85 per cent in certain peanut fields and a total loss in certain parts of infested fields. Whether this insect is gaining in numbers since it was first observed in 1939 is not known.—10-20-42.

The Abundance of *Microctonus epitricis* (Vier.) in Virginia

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The presence of the tobacco flea beetle parasite, *Microctonus epitricis* (Vier.), in Virginia was reported by Dominick & Wene in 1941. The study of this parasite was continued during 1941 and 1942. Collections of flea beetle adults were made at Chatham on the dates shown in table 1 in order to determine the percentage of adults parasitized, also, a series of collections were made in the counties shown in table 2.

Flea beetles were collected from tobacco fields near Chatham and placed in lantern globe cages, usually about 100 to a cage. This cage was made as follows: the top was covered with white muslin, and the base was made up of white cardboard with a covering of one thickness of black muslin and then one thickness of black cheesecloth. The larva of the parasite when fully developed leaves the flea beetle through the insect's vent, and usually spins its cocoon between the cheesecloth and muslin. The cages were examined daily. A small tobacco leaf was placed in the cage every day, so that the beetles would have something on which to feed.

Table 1.—A two-year survey of the per cent of tobacco flea beetles parasitized by *Microctonus epitricis* (Vier.) at Chatham.

Collection Date	Where Collected	Number of Beetles	Parasites	
			number	per cent
1941				
March 15	Under leaves	254	27	10.6
May 5 to 6	Potatoes	800	70	8.8
May 22	Tobacco	800	84	10.5
June 17 to 19	Tobacco	800	115	14.4
July 11	Tobacco	700	116	16.6
July 30	Tobacco	800	34	4.3
August 22	Tobacco	860	33	3.8
September 3	Tobacco	715	21	3.2
1942				
March 26	Under leaves	19	1	5.3
April 25 to 29	Potatoes	445	26	5.8
May 25 to 26	Tobacco	550	29	5.3
June 24	Tobacco	675	90	13.3
July 22	Tobacco	875	32	3.7
August 20	Tobacco	800	3	0.04

Table 2.—Parasitism of the tobacco flea beetle by *Microctonus epitricis* (Vier.) in Virginia, 1941.

County	Collection Date	Number of Beetles	Per Cent Parasitism
Halifax	July 14	945	17.8
Charlotte	15	888	15.0
Franklin	18	998	16.7
Henry	18	532	9.0
Mecklenburg	Aug. 1	845	5.3
Brunswick	1	800	6.9
Halifax	1	735	4.9
Charlotte	4	893	4.3
Franklin	5	767	8.7
Henry	5	784	10.7
Halifax	19	780	9.6
Henry	20	813	7.8
Franklin	20	844	4.1
Charlotte	21	650	3.4
Washington	Sept. 1	530	13.8

As previously reported, the parasitism of beetles collected in 1940 ranged from 25.4 per cent for those taken July 22–26 to 9.7 per cent for those collected August 19. The parasitism of beetles in 1941 ranged from 16.6 per cent for the collections made July 11 to 3.2 per cent for those collected September 3. In 1942 the parasitism of beetles ranged from 5 per cent for those collected in early season to a high of 13.3 per cent for beetles taken June 24 and a low of 0.04 per cent for beetles collected August 20. Table 2

shows the percentage of flea beetles parasitized in other tobacco sections. The parasite was found in every county where collections were made. The highest percentage was the 17.8 found in Halifax County on July 14.

The percentage of flea beetles parasitized by *Microctonus epitricis* (Vier.) varied from a high of 25.4 in July 1940 to a low of 0.04 per cent on August 20, 1942. The flea beetle parasite was found throughout the remaining tobacco producing counties in Virginia. The per cent of parasitism was low in these counties with the highest percentage being 17.8.—12-4-42.

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Some New Killing Fluids for Larvae of Insects

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In the 1942 October issue of the JOURNAL, Hutzel & Peterson presented information on a satisfactory killing and preserving fluid for immature insects. Unfortunately the ketone used in the ketone-methyl alcohol-acetic acid mixture reported upon is not available during the present war emergency. In view of this situation the following substitute, yet satisfactory, mixtures are submitted.

During the past few years the author and some of his students have tried out many chemical mixtures. Three of these have produced worth while specimens, namely:

1. *X.A.* mixture; xylene—1 part and 95 per cent ethyl alcohol—1 part.
2. *X.A.A.D.* mixture; xylene—4 parts, commercial refined isopropyl alcohol—6 parts, glacial acetic acid—5 parts, and dioxan—4 parts.
3. *K.A.A.D.* mixture; kerosene—1 part, 95 per cent ethyl alcohol or refined commercial isopropyl alcohol—7 to 9 parts, glacial acetic acid—1 part and dioxan—1 part.

The *X.A.* mixture (xylene and alcohol) was first used by C. B. Huffaker on larvae of the southern armyworm. This proved to be quite satisfactory for this insect. L. D. Anderson of Norfolk, Virginia, gave this mixture a fairly extensive trial during one entire season (1941) and learned that many larvae of Lepidoptera, Coleoptera and some Tenthredinoidea killed in this mixture resulted in very satisfactory specimens.

The *X.A.A.D.* mixture (xylene, isopropyl alcohol, glacial acetic acid and dioxan) was first used by R. A. Blickle at Durham, N. H., in 1941. This solution, with limitations, is also quite satisfactory for many larvae of Lepidoptera and Coleoptera.

The *K.A.A.D.* mixture (kerosene, alcohol, acetic acid and dioxan) is the result of a joint effort by Clyde F. Smith, Sue D. Sparks and the author. Dr. Smith of Raleigh, North Carolina, reported to the author early in 1942 his interesting results with a mixture of kerosene—1 part and 95 per cent alcohol —9 parts. At this time we were conducting tests at Ohio State University with various chemicals, including oils, and learned early that a kerosene, alcohol, acetic acid and dioxan mixture gave very promising results with blow fly maggots, southern armyworms and honey bee larvae and pupae. The acetic acid in the mixture prevents darkening of many light colored larvae after they are dead and preserved in alcohol. The dioxan increases the miscibility of most kerosenes in the mixture and also improves the specimens among some species. It can be omitted for many larvae.

After one season's experience with many species of larvae it can be said that the *K.A.A.D.* mixture in general produced more satisfactory specimens for more species of larvae among the Lepidoptera, Coleoptera, Diptera, Hymenoptera and Neuroptera than the *X.A.* or *X.A.A.D.* solutions. For most species the *K.A.A.D.* mixture equals, or is slightly superior to, the ketone mixture, also in many cases it produced specimens as good (or nearly so) as a hot water killing method. In general this solution produced excellent specimens among most soft bodied larvae, particularly among terrestrial species. It does not produce satisfactory specimens where larvae possess a thick exoskeleton, namely wireworms and similar species or among some aquatic insects especially immature stages of Zygoptera and Ephemeroptera.

It has also been learned that the use of highly refined commercial isopropyl alcohol in place of 95 per cent ethyl alcohol in the *K.A.A.D.* mixture may prevent explosion of exceedingly soft bodied larvae (blow fly maggots, etc.). Apparently the isopropyl alcohol reduces the rate and the extent of the impregnation of the material into the specimens, thus largely eliminating explosion by excessive inflation. Isopropyl alcohol also increases the miscibility of the kerosene in the mixture. One may also reduce or prevent the explosion of soft-bodied larvae by reducing the proportion of kerlsene in the mixture.

Larvae collected in the field are dropped into the killing solution and kept submerged until they are completely distended. If narrow vials are used (for large larvae) they should be placed in a horizontal position until the larvae straighten out and become firmly set. This may take from one to several hours, depending upon the species. At the end of this period the larvae should be transferred to ethyl alcohol. Larvae possessing a firm exoskeleton may be preserved in 75 per cent ethyl alcohol, while soft bodied forms killed in a *K.A.A.D.* mixture should be preserved in 95 per cent ethyl alcohol, to prevent any collapse. The clear killing solution upon use may become cloudy and some of the kerosene appears to separate from the mixture. This change apparently does not influence the results.

The *K.A.A.D.* mixture (with modifications) also gives promise of becoming a satisfactory killing and fixing agent for internal tissues. It has been noted that the internal organs of a large sphingid larva were in excellent shape for gross dissection six months after they have been killed and preserved in 70 per cent alcohol. Clyde F. Smith reports that increasing the kerosene content to two parts (20 per cent) improves the condition of the internal organs for dissection.

The author and his students expect to continue their search for an ideal killing and preserving agent for immature insects. Any suggestions or comments on results obtained with the above mixtures will be welcomed.—11-22-42.

[1] Assisted by C. B. Huffaker, L. D. Anderson, R. A. Blickle, C. F. Smith and Sue D. Sparks.

Damage to Strawberry Fruit by Small Darkling Beetles (*Blapstinus* spp.)

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Small darkling ground beetles (*Blapstinus* spp.)[1] were observed by the writers damaging strawberry fruits at Oceanside, Calif., in February 1942. Damage to several plants by beetles of this genus has been reported by Campbell (1922, 1924) and Essig (1926), but apparently no mention has been made of fruit damage.

When the field at Oceanside was first examined on February 12, about 50 per cent of the fruit had been attacked. The damage consisted of shallow round or irregular holes ranging from one-sixteenth to nearly one-fourth inch in diameter, and most of the damaged berries had to be discarded (Fig. 1). Beetles confined in salve cans with undamaged berries produced holes or scars similar to those found in the field.

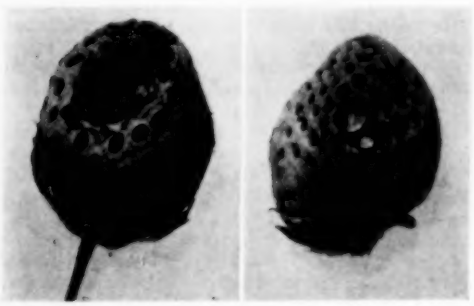

FIG. 1.—Typical damage to strawberries by small darkling ground beetles.

The writers suggested the use of a poisoned bait of the following formula: Bran 20 pounds, Paris green 1 pound, molasses 1 quart, and enough water to make a crumbly mash. This bait was prepared and applied along the rows to the entire field (40 acres) at the rate of about 5 pounds per acre from February 15 to 18. On February 19 another examination was made, and counts of dead and live beetles showed about 50 per cent kill and a reduction in population from 1.1 to 0.5 beetle per plant. Fruit damage had dropped to about 10 per cent, which was inconsistent with the percentage of kill, but this was probably due to the fact that the more voracious beetles were also more susceptible to the bait treatment.—11-30-42.

[1] Determination by R. E. Blackwelder.

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Epitrimerus pyri Nal. in New York

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Medina, New York

During the growing season of 1942 considerable russet was noted on normally smooth skinned pears such as Bartlett. Various causes were assigned to this including the possibility that the russet was due to frost or spray injury or a combination of both. However, russet was present in unsprayed orchards so spray injury seemed to be eliminated as a cause.

The writer was struck by the peculiar silvery sheen of the russeted pears and close examination showed that both leaves and fruit were covered with minute yellowish white mites. Specimens were sent to Dr. H. H. Keifer of the California Department of Agriculture who kindly determined these mites as *Epitrimerus pryi* Nal. Dr. Keifer regards these mites from New York as distinct from the western form, *E. pyrifoliae* Keifer, but believes the eastern form has the same type of deuterogynous development as *E. pyrifoliae*. Apparently *E. pyri* has never been reported as a pest of pears in New York.

In western New York, injury first became quite noticeable early in July and by the end of July severe injury could be found in many orchards. Injury was confined largely to pears on the outside of the tree and to the terminal growth. In heavily infested orchards the russet of the terminal leaves was so severe that leaves became leathery and black and growth stopped. On the fruit, the russet first showed on the calyx end and gradually covered the whole fruit. Injury to the fruit hanging inside the tree was confined largely to a russeted area at the calyx end of the fruit. The mite population declined during August and few mites were present when the fruit was harvested in late August and early September.

Orchards most severely infested were in Niagara County but infested orchards were found throughout the entire Lake Ontario fruit belt as far east as Oswego.

The writer found that 1.5 per cent summer oil gave excellent control of the mites when applied from the ground so that the fruit and lower surface of the leaves were well covered. It is suggested that the large population of *Epitrimerus pyri* in 1942 may have been due to the low population of pear psylla and the resultant omission of the summer oil sprays usually used for this pest.—2-1-43.

Acrylonitrile and Trichloroacetonitrile in Admixture with Carbon Tetrachloride as Possible Fumigants for Stored Grain

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During the course of a search for fumigants suitable for the treatment of stored grain, two nitriles have been tested that show considerable toxicity to stored-grain pests.

Acrylonitrile (CH_2:CHCN), a compound being produced for industrial purposes, is a colorless liquid with the following physical constants: Molecular weight 53.06; boiling point 77.3–77.5° C.; freezing

point −82°; specific gravity (liquid) 0.801 at 25° C. (referred to water at 4° C.); solubility in water 7.0 per cent by weight; flash point 4° C.; inflammable limits (in air) upper 17 per cent by volume, lower 3.05 per cent by volume. It is miscible in all proportions with carbon tetrachloride, and in admixture with equal volumes of carbon tetrachloride it is noninflammable.

The toxicity of acrylonitrile to warm-blooded animals has been studied by Dudley & Neal (1942). These investigators conclude from their study of the effect on rats, rabbits, guinea pigs, cats, dogs, and monkeys of exposure to acrylonitrile that the symptomatology of all animals (except guinea pigs) indicates its action to be that of a typical nitrile and its toxicity to be probably due to cleavage of the molecule, producing hydrogen cyanide. Guinea pigs showed a marked resistance to the effects of this nitrile, whereas dogs were killed by concentrations that had but slight effect on the other species studied. A concentration of 1.38 mg. per liter (635 p.p.m.) for 4 hours was fatal to rats, whereas 0.24 mg. per liter (110 p.p.m.) for 4 hours was fatal to dogs. Exposure to 90 p.p.m. produced but slight transitory effects on monkeys.

In 5 replicated laboratory tests conducted in 20 liter glass bottles, in each of which 150 test insects were used, the dosages of 99.5 per cent acrylonitrile required to give a 100-per cent kill in 24 hours at 72° F. was, for the rice weevil, *Sitophilus oryza*, 1.6 mg. per liter and for the confused flour beetle, *Tribolium confusum*, 5 mg. When the 20-liter containers were filled with wheat (one-half bushel), the dosage required to give a perfect kill in 24 hours was for the rice weevil 8 mg. per liter, or an estimated 0.7 lb. per 1000 bushels of wheat, and for the confused flour beetle 16 mg., or 1.4 lb. per 1000 bushels.

In the presence of wheat under laboratory conditions the effect of a given quantity of a mixture of equal parts by volume of acrylonitrile and carbon tetrachloride is approximately the same as that of the acrylonitrile used alone. Admixture with carbon tetrachloride eliminates the fire hazard. In the treatment of farm-stored grain with other fumigants it has been determined that the addition of 1 gallon of carbon tetrachloride per 1000 bushels of grain aids in the distribution of the fumigant by increasing its volume and thereby improves the over-all kill. Presumably this would also be true of the acrylonitrile-carbon tetrachloride mixture.

Preliminary milling and baking tests indicate that if treated grain is milled without aeration, the milling quality is somewhat adversely affected whereas the baking quality is improved. The adsorbed fumigant apparently largely disappears with aeration.

Trichloroacetonitrile (CCl_3CN) is a transparent, occasionally somewhat yellowish liquid with the following physical constants: Molecular weight 144; boiling point 85° C.; freezing point about −42° C.; specific gravity (liquid) 1.44 at 25° C. (referred to water at 4° C.). It is noninflammable and is slightly corrosive to iron and steel. It is relatively toxic to human beings, but the vapors in low concentrations produce great irritation to the mucous membranes of the nose, throat, and eyes, so that anyone entering an appreciable concentration is forced to leave. The use of trichloroacetonitrile as a fumigant for buildings has been described by Peters (1940).

In laboratory tests by the present writers this material was mixed with carbon tetrachloride at the rate of 1 part by volume of 97.0 per cent trichloroacetonitrile to 19 parts by volume of technical grade carbon tetrachloride. At this dilution it can be handled in the laboratory withouts erious discomfort. In addition to reducing the lachrymatory effect of the chemical, carbon tetrachloride would act as a carrier gas to aid in the distribution of the fumigant if it were to be used in the treatment of bulk grains.

Tests in 20-liter glass bottles indicate that for a 24-hour exposure at 72° F. the minimum lethal concentration of the 1 to 19 mixture by volume for the rice weevil is 47 mg. per liter. The trichloracetonitrile in this concentration is 2 mg. per liter.

Similar tests in 20-liter glass bottles filled with wheat indicate that for the same exposure the minimum lethal dosage for the rice weevil is 396 mg. per liter of the mixture or an estimated 35 lb. per 1000 bushels of wheat. The quantity of trichloracetonirile in this dosage is approximately 1.5 lb. per 1000 bushels. The confused flour beetle is more susceptible to this fumigant than is the rice weevil, the minimum lethal dosage for this insect under the same conditions being 95 mg. of the mixture per liter, or an estimated 8.4 lb. per 1000 bushels of wheat. The quantity of trichloroacetonitrile in this dosage is 0.38 lb. per 1000 bushels.—10-29-42.

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Influence of Changes in Relative Humidity on the Effect of Certain Insecticides on Newly Hatched Codling Moth Larvae

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Several factors are known to modify the effect of various codling moth insecticides on newly hatched larvae. These include the distribution, physical nature, and age of the deposits, the particular chemical tie-up with any supplements which might be used, and temperature. Evidence was obtained in 1941 that fluctuations in the relative humidity may also be responsible for immediate substantial changes in the toxicity of nicotine bentonite-copper phosphate and to a lesser extent of nicotine bentonite, phenothiazine, and lead arsenate-bordeaux.

The laboratory-field method, whereby fruit sprayed in the normal manner is brought into the laboratory and exposed to the attack of a known number of larvae, was used in these experiments.

Stratified samples of 120 apples were taken from each of 5 sprayed plots and from unsprayed trees on August 25. The apples had been subjected to 12 days of growth and weathering, including 1.28 inches of rainfall, after the eighth and final cover spray.

Each sample was divided into two equal lots, one being set up for infesting in the laboratory under a constant temperature of 81° F. and relative humidity of 74 per cent. The duplicate lot was set up in a well-ventilated screened insectary. Ten newly hatched larvae were applied concurrently to one apple from each plot and location, those apples from the in-

Table 1.—Effect of relative humidity and temperature on the larvicidal efficiency of spray deposits on apples.

Spray Treatment, Quantity per 100 Gallons	Difference in Per Cent Larvicidal Efficiency Between Insectory Lot and Laboratory Lot[1]			
	Relative Humidity, Per Cent		Temperature, °F.	
	71–80 (110 Larvae)	59–62 (90 Larvae)	73.5–84.0 (290 Larvae)	63.0–73.5 (310 Larvae)
Lead arsenate 3 lb., copper sulfate 0.75 lb., lime 1.5 lb.	+3.1(72.2)	+0.4(76.0)	−0.5(81.6)	+2.3(76.7)
Lead arsenate 4 lb., copper sulfate 4 lb., lime 8 lb.	+9.2(77.8)	−1.9(79.7)	−3.7(83.8)	+9.4(76.3)
Micronized phenothiazine 2.7 lb.	− .6(91.1)	−15.3(89.9)	−9.4(94.6)	+4.7(87.7)
Tank-mix nicotine bentonite (40% nicotine sulfate ⅔ pt., Wyoming bentonite 3.3 lb., crude soybean oil 1 qt.)	+.7(92.2)	−12.1(89.9)	+.4(87.1)	+1.0(89.0)
Tank-mix nicotine bentonite as above plus copper phosphate 6 oz.	+3.5(78.9)	−31.1(79.7)	−17.3(82.5)	−4.0(76.7)

[1] Figures in parentheses show per cent larvicidal efficiency of laboratory lot.

sectary being held in the laboratory only long enough for the larvae to be put on the fruit. The larvae were applied from August 26 to August 28. In the insectary the temperature, according to readings taken 1 hour after application of the larvae, ranged from 63° to 84° F. and the humidity from 59 to 80 per cent. The means of both temperature and humidity were lower under insectary conditions than in the laboratory.

Larvicidal efficiencies were calculated on the basis of successful worm entrances in the sprayed apples as compared with those in an unsprayed check sample infested concurrently and held under the same conditions. Eight days after application of the larvae the apples were examined and successful entrances recorded. In the insectary 75.7 per cent of the larvae entered unsprayed apples and in the laboratory 80.8 per cent, the difference being highly significant.

The larvicidal efficiency of the spray deposits on apples held in the insectary under different conditions of humidity and temperature and on paired apples held in the laboratory is shown in table 1 for each spray treatment. Because of differences in larval vigor, the rate of survival under controlled conditions was not constant. Therefore, the larvicidal efficiency of the paired sample held in the laboratory was in each instance taken as the standard for comparison.

In the insectary the low humidity was associated with high temperature, the latter being in general lower than that in the laboratory. It is therefore probable that low humidity rather than high temperature was the cause of differences in larvicidal efficiency. In the insectary high humidity accompanied low temperature, the humidity being not far different from that in the laboratory. In these cases low temperature was probably responsible for changes in mortality.

No significant difference occurred between the paired samples of lead arsenate, copper sulfate, and lime at the weak concentration. The same materials at a stronger concentration gave increased toxicity at the higher humidities and at the lower temperatures. In other experiments prolonged dry weather reduced the toxicity of lead arsenate, but the change was slow and the lowered toxicity persisted even after the apples were held in a higher humidity for 2 or 3 days.

There was evidence that phenothiazine and tank-mix nicotine bentonite without copper phosphate might lose toxicity under relatively dry conditions. The efficiency of tank-mix nicotine bentonite with copper phosphate was decidedly reduced under lowered humidity.

The experiments suggest a possible reason for regional differences in the relative effectiveness of certain insecticides, particularly where there are substantial differences in the relative humidity during the periods of maximum larval hatch, such as between the Middle West and arid regions in the Pacific Northwest.

The methods by which changes in relative humidity regulate toxicity remain to be determined, but the rapidity of the change suggests that some factor affecting the amount of toxicant contacted or ingested is involved.—11-30-42.

The Occurrence of Physiological Races of the Pea Aphid

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During the winter of 1941–42 colonies of pea aphids, *Illinoia pisi* Kalt., were collected from New Jersey, Virginia, Alabama, Wisconsin, Kansas, Utah, Oregon, and California. The purpose of these collections was to determine whether separate physiological races of the insect occurs in the United States. One or more pure lines were started from each colony through isolation of a single agamic insect and its subsequent progeny. The number was reduced to nine which, carefully isolated, were maintained throughout the winter under uniform environal conditions. In early spring 50 adult aphids of uniform age from each line were measured. Variation within lines as to body length and width was negligible, but the differences between lines were highly significant. The lines could be arranged into four distinct size classes. In late spring their comparative virulence was determined by counting the numbers of progeny which uniformly aged aphids of each line

were able to produce in a given period of time under similar temperature conditions. Three varieties of peas were used as host plants and the data was subjected to the analysis of variance procedure.

Variation within lines was found to be negligible; between lines, however, clear cut differences were present. Two lines exhibited extremely high virulence, two other lines showed high virulence, four lines were intermediate, and one line was of low virulence. These results were in exact agreement, line by line, with results secured when the insects were measured, high virulence apparently being associated with added size. The data indicates that at least four physiological races of the pea aphid are present in the United States, the races differing significantly from one another in both size and virulence. Further studies are underway to determine if additional races occur.—12-8-42.

Scolytus sulcatus Lec. in Western New York

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Several years ago the writer (1938) attempted to determine the distribution of *Scolytus sulcatus* in eastern United States. Since *S. sulcatus* was a potential fruit tree pest, a careful survey was made in the western New York fruit area, but it was not found.

On June 20, 1940 the writer was asked to look at an unusual type of injury in a sweet cherry orchard at Pekin, Niagara County, New York. It was found that the leaves on the leaf and fruit spurs were wilting and browning due to injury at the base of the spur; in some cases the base of the spur was completely cut through and the spur was hanging by a strip of bark. Most of these wounds were occupied by a specimen of *Scolytus sulcatus* which was feeding in the crotch between the spur and the twig.

The source of the infestation was quickly traced to a wood pile on the edge of the orchard where *Scolytus sulcatus* was emerging by the thousands from apple, sweet cherry and prune wood. There was little injury farther than one hundred yards from the wood pile, but within that distance some trees had nearly every fruit spur destroyed. A few apple and sour cherry trees nearby were attacked but the insects seemed to prefer the sweet cherries. *S. sulcatus* was also attempting to enter the trunks and larger branches of the sweet cherries but the copious flow of sap prevented this. The trunk and larger branches of many of the trees were covered with a solid sheet of gum which had run from the unsuccessful entrance tunnels and then hardened.

Within two weeks all the leaves on the damaged spurs had turned brown and the trees had a very poor appearance.

In 1941 and 1942 the writer found a few other such attacks by *Scolytus sulcatus* in western New York but none as serious as the 1940 infestation. In all cases the source of the infestation could be traced to woodpiles.—2-1-43.

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Influence of Moth-Trapping Methods on the Proportion of Females in the Catches

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Differences in the proportion of females among captured moths, depending upon the means used for collection, have been of interest at the Dried Fruit Insect Laboratory of the Bureau of Entomology and Plant Quarantine at Fresno, Calif., for some time. Considerable data on the night-flying adults of the grape leaf folder, *Desmia funeralis* (Hbn.), and the raisin moth, *Ephestia figulilella* Greg., have been accumulated. The moths examined were from three sources, namely, malt-sirup traps, a rotary net (Barnes *et al.* 1939), and collections of reared larvae.

The bait traps used were enamel pails 8.5 inches in diameter, which held about 2 quarts of liquid bait as an attrahent. The bait consisted of one-fourth pint of malt sirup, one-sixth cake of compressed yeast, and water to make 2 quarts. It was renewed twice each week. These traps were exposed continuously in San Joaquin Valley vineyards and fig orchards during the flight seasons from 1931 to 1934 and 1939 to 1941.

Table 1.—Proportion of females among moths from the different sources.

SPECIES AND SOURCE	NUMBER OF MOTHS EXAMINED	PERCENTAGE OF FEMALES
Grape leaf folder:		
Malt-sirup traps	13,194	60
Rotary net	837	34
Collections of reared larvae	846	50
Raisin moth:		
Malt-sirup traps	67,096	46
Rotary net	36,383	31
Collections of reared larvae	2,079	49

The rotary net, a nonselective apparatus, was operated continuously in a fig orchard in 1937 and in a raisin storage in 1938 and 1939. Captured insects, including the raisin moth, were removed and examined once each day. On certain nights the flight activity was followed by examinations at 15-minute intervals, beginning before and ending after the daily flight periods. Catches of the grape leaf folder were made on the night of August 15–16, 1941, when the net was operated during the flight period in a heavily infested vineyard. Examinations were made at 15-minute intervals.

Adults of the raisin moth were reared from larval collections made in vineyards, orchards, and raisin storages. Adults of the grape leaf folder were reared from larvae collected in vineyards. Data on moths obtained from the three sources are summarized in table 1.

The random nature of the sampling, when larvae were collected, leads to the belief that sex ratios obtained from the rearings are dependable as controls. With these two species of moth approximately 50 per cent of the reared adults were females. The reductions from this figure shown by the rotary net seem to be due to the different flight habits of the

sexes. Examination of the rotary-net catches at 15-minute intervals during active flight periods showed that with both species flight began about 45 minutes after sunset. The greatest activity occurred in the first 2 or 3 hours of flight, when females predominated. Flight continued all night, on warm nights at least, but the males were most abundant during the balance of the night. The longer period during which males may be taken permitted larger numbers of that sex to be captured, and consequently the proportion of females decreased.

The differences in sex ratios between the reared material and that taken in bait traps has not been satisfactorily explained. The percentage of females caught in bait traps was less than 50 for the raisin moth and more than 50 for the grape leaf folder.—12-8-42.

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The Collection, Rearing, and Release of Parasites of the European Corn Borer in 1942[1]

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To furnish parasites for release in 1942, overwintering corn borer larvae were collected in two localities, central Connecticut and southeastern Massachusetts, in the fall of 1941. Several of the most important parasites of the European corn borer imported from Europe and the Orient are established and abundant in these localities.

Collections were made in central Connecticut during the period October 27 to November 15, 1941. A total of 14,214 host larvae, or an average of 861 per working day, were obtained. Collections in southeastern Massachusetts were made during the period November 12 to 25 but, owing to a very light plant infestation, only 368 larvae were obtained per working day. The 3735 larvae from southeastern Massachusetts brought the total number of host larvae available to 17,949. These larvae were placed in collecting cans in the field and shipped by railway express to the Moorestown, N. J., corn borer laboratory, where they were placed in cold storage for the winter at 35° F., and approximately 70 per cent relative humidity. The larvae were given contact water at monthly intervals. In the spring of 1942 they were isolated individually in 1-inch glass vials. In order to have adult parasites available at the right time for release where needed, the material was held in cold storage until June 1, when it was removed and placed in an incubator room. The temperature was gradually raised to 80° and the relative humidity was maintained at approximately 70 per cent.

Four exotic species of parasites.—*Macrocentrus gifuensis* Ashm., *Inareolata punctoria* Roman, *Lydella grisescens* R. and D., and *Chelonus annulipes* Wesm. were reared from the host material collected the previous year. Approximately 15,000 adult parasites were reared, of which approximately 75 per cent were adults of the polyembryonic *M. gifuensis* from borers collected in southeastern Massachusetts.

Table 1.—Releases of European corn borer parasites during 1942.

Release Locality			Parasites Released	
State and County	Township	Date of Release	*Inareolata punctoria*	*Macrocentrus gifuensis*
			Number	*Number*
Illinois:				
Vermilion	Grant	July 4	594	1,895
Indiana:				
Tipton	Wildcat	June 30	595	1,965
New Jersey:				
Burlington	Burlington	July 6	148	—
		Aug. 8	165	1,019
		Aug. 11	—	2,244
Pennsylvania:				
Montgomery	Skippack	June 28	590	2,068
Wisconsin:				
Sheboygan	Wilson	July 4	600	1,949
Total			2,692	11,140
Grand total[1]	14,023			

[1] Including 48 *Chelonus annulipes* released at Burlington, N. J. on June 24 and 743 *Lydella grisescens* released at Sheboygan, Wisconsin, on June 25.

Parasite releases were made in the five states, Illinois, Indiana, New Jersey, Pennsylvania, and Wisconsin. Because of the small numbers available, the egg-larval parasite *Chelonus annulipes* was released only in New Jersey and the tachinid *Lydella grisescens* only in Wisconsin. The ichneumonid *Inareolata punctoria* and the braconid *Macrocentrus gifuensis* were released in all five of the states listed.

All releases, with the possible exception of those made in Wisconsin, were accomplished at a time and under host-infestation conditions to afford the parasites a favorable opportunity of becoming well established.

The releases of corn borer parasites liberated during the 1942 season are listed in table 1.—2-10-43.

[1] For releases prior to 1942 see Insect Pest Survey Bul., v. 21, Suppl. to No. 8, Oct. 15, 1941.

The Occurrence of the Potato Tuber Worm in Nebraska[1]

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A sample of potatoes showing tuber worm injury was submitted to the Entomology Department by a farmer of Elmwood (Cass County), Nebraska in September 1939. A few days later the farm was visited and a bin of about 125 bushels of potatoes was found to be heavily infested with the potato tuber worm. In compliance with instructions, the grower either used or destroyed the entire crop during the early part of the ensuing winter. Potato fields in the same vicinity were examined the following year, but no specimens or evidence of injury by this pest could be found. Apparently, this is the first record of the potato tuber worm, *Gnorimoschema operculella* (Zell.), in Nebraska.

In August, 1940 potato tuber worm larvae were collected in small numbers, both in growing plants

[1] Published with the approval of the Director as Paper No. 322, Journal Series, Nebraska Agricultural Experiment Station.

and later in cull tubers left in the field, near Lincoln (Lancaster County), Nebraska. Although the same area was planted in potatoes the following year (1941), there was no evidence of tuber worm injury.

The exact source could not be ascertained, but on the basis of available information it seems evident that the seed stock for the above fields was obtained by local wholesale dealers from outside the state.

In the spring of 1942 the Department of Entomology in cooperation with the U. S. Bureau of Entomology and Plant Quarantine began a potato tuber worm survey of Nebraska. During the growing season of this year (1942) from 100 to 300 plants were examined in each of about 75 different fields of potatoes, more than half of which were in the seed producing area of western Nebraska. Also, large numbers of other Solanaceous plants, including eggplant (*Solanum melongena*), buffalo bur (*S. rostratum*), horse nettle (*S. carolinense*), and several species of nightshade (*Physalis* spp.) were examined. The potato tuber worm was found in small numbers on growing potato plants in four localities; namely, Lincoln (Lancaster County), North Platte (Lincoln County), Kearney and Gibbon (Buffalo County), and Alliance (Box Butte County). At Alliance only two specimens were found, although extensive searches were made both during the growing season and following harvest, and at North Platte only a single specimen was found.

Seed potatoes in eastern Nebraska, where commercial plantings are relatively small, are obtained to a large extent from outside sources. In central Nebraska a considerable proportion of the seed stock also is obtained from other states; and except for a short interval during and immediately following harvest, a large proportion of the table stock in each of these localities is obtained from other areas. In western Nebraska seed stock is entirely of local origin except possibly for occasional isolated instances, and table stock is largely home grown, but there is sufficient importation of the latter to easily account for the single isolated infestation found here. These records along with certain observations suggest that the tuber worm infestations have resulted from seasonal importation, especially in the western commercial seed producing area. This probability is given further support by the fact that the tuber worm previously has been taken in a number of other mid-western states, including North Dakota, South Dakota, Minnesota, Iowa and Colorado, but apparently has not become established.—11-30-42.

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Studies of the Flight Range of Mosquitoes

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For 25 years I have been under the impression that male mosquitoes remain near their breeding places. Often it has been observed that mosquitoes swarm and mate at marshes and that the males remain near the breeding places. It is a sort of rule of thumb among mosquito workers, to look for males as an indicator to nearby breeding. In my experience I have thought that this observation has worked very satisfactorily. In sleuthing for hidden breeding places of Anopheles and Culex I have been under the impression, many times, that I have been rewarded. In tracing the source of *Aedes vexans* in villages I am guilty of having instructed our inspectors to look for male mosquitoes in order to determine whether or not vexan annoyance originated in nearby wet lots rather than from long distance flights. I have never found in literature any proof that the female of the species flies farther than the male.

With these thoughts in mind an opportunity presented itself during the past summer to prove or disprove this rule of thumb. There was a large marsh perhaps 40 acres in extent which had been flooded, the flood waters had receded leaving concentrated pools of perhaps 12 acres teeming with mosquito larvae. The rains had not been sufficient to cause vexans breeding generally only several large marshes within flight range of the district would produce large broods. From these marshes to the west and south of the District I expected only a mild annoyance from flight. Having on hand already mixed a sufficient quantity of aniline dye I decided to dust this area and trace the flight of both male and female mosquitoes. This was done by carefully observing the progress of the larvae in order to apply stain to both males and females. As soon as the males began to emerge the marsh was dusted with brown aniline dye, the next day with red aniline dye, the third day with violet, the fourth day with yellow. In this way the entire brood was stained. Following the dusting, mosquitoes were caught in 12 New Jersey light traps stationed at varying distances from 1 to 14 miles away. Catches were made over a period of 52 days, during the first 17 days catches were made each night, thereafter twice each week. The total number of mosquitoes in the traps was 23,000. To date 12,000 mosquitoes have been examined yielding 72 stained mosquitoes, a ratio of 1 stained mosquito to 166 unstained.

I might digress here a moment to state that, in the staining experiments carried out in this District in 1936, the method of catching was entirely different. In the 1936 experiment, after staining the mosquitoes in the marshes, they were recovered by hand-catching using a test tube with ether-soaked cotton. Four men in four trucks caught during the day over a period of 39 days. In this experiment only day-biters were captured and only females; whereas in the experiment of 1942 the New Jersey traps yielded all species including the non-biters as well as females and males in which I was particularly interested.

The New Jersey traps caught a total of 23,000 mosquitoes, one-half of which have been examined to date. These consisted of 4378 males and 7629 females. Each of these mosquitoes was dipped in an aniline dye solvent under a low power microscope. Seventy-two specimens were found to be stained, 32 males and 40 females.

Referring to table 1 it will be noted that the males of *Aedes vexans* and *Culex pipiens* fly as far as the females. Insufficient numbers of *Culiseta inornatus*, *Anopheles punctipennis* and *Anopheles quadrimaculatus* were recovered to compare the relative flight range of males and females.

IS THE FLIGHT RANGE OF ALL MOSQUITOES THE SAME?—Fortunately during this experiment there were six species of mosquitoes emerging at the time

the marsh was dusted, *Aedes vexans* and *Culex pipiens* constituted the larger numbers. However there were present in lesser numbers *Culiseta inornatus*, *Anopheles punctipennis*, *Anopheles quadrimaculatus* and *Psoraphora ciliata*.

The table given below shows the average distances and the maximum distances flown by stained specimens of each of these species except *Psorophora ciliata*.

Table 1.—Comparison of flight range of male and female mosquitoes.

Distance in Miles from Marsh	Number and Species of Stained Mosquitoes Recovered						
	Aedes vexans		*Culex pipiens*		*Culiseta inornatus*		
	F	M	F	M	F	M	Total
1	3	1	3	1	1		9
1.5	1						1
2.75							0
5	1						1
5.5	1						1
6		1		2			3
8	3	3					6
8		7		4			13[1]
9.5	2		2	2			6
10.25	3						3
14	6	9	10	2	1		28[2]
Totals	20	21	15	11	2	0	72[1]

[1] Includes one *Anopheles punctipennis* and one *A. quadrimaculatus*, both females.
[2] Including one *A. punctipennis* female at 10.5 miles.

It will be noted in table 2 that on the first day after application of each color the maximum distance flown by *Aedes vexans* was 14 miles and that the maximum distance flown by *Culex pipiens* during the first day was 9½ miles. These distances were flown, in from 4 to 16 hours, as the dusting of the marshes was stopped at about 3 P.M. The traps were timed to go on at 7 P.M. and go off at 7 A.M.

The question has arisen whether or not the distances shown in the tables are covered in a single initial flight or by progressive flights. There are instances in the table showing that the maximum flight was made in less than 16 hours. However, the column showing average distances would indicate that for the first three days both vexans and pipiens reached the point of capture by progressive flights.

Table 2.—Average and maximum flight range of several species of mosquitoes on the 1st day and subsequent days after application of each color at breeding grounds.

Day	*Aedes vexans*			*Culex pipiens*			*Culiseta inornatus*		
	No.	Ave. Dist.	Max. Dist.	No.	Ave. Dist.	Max. Dist.	No.	Ave. Dist.	Max. Dist.
1st	8	5.5	14	2	7.7	9.5			
2nd[1]	2	9	10	1	9.5	9.5			
3rd	7	13.4	14	1	14	14			
4th	9	12.4	14	5	14	14			
5th				3	9	9.5	1	14	14
6th				3	6.3	9.5	1	1	1
7th[2]	9	8.6	14	6	6.8	8			
8th	1	1.5	1.5						
9th	2	3.1	5.25	1	1	1			
10th	1	14	14	1	6	6			
11th									
12th				4	14	14			
13th									
14th				1	14	14			

[1] *Anopheles quadrimaculatus*, one specimen at 8 miles, on second day.
[2] *A. punctipennis*, one specimen at 7 miles and 1 at 10.5 miles on seventh day.

Table 2 shows that one of the two *Culiseta inornata* reached a maximum distance of 14 miles, that two *Anopheles punctipennis* averaged nine miles reaching a maximum distance of 10.5 miles and that one *Anopheles quadrimaculatus* reached a maximum distance of 8 miles on the second day after staining. The longest recorded distance flown by *Anopheles quadrimaculatus* heretofore, 2.7 miles, was reported by Darling, 1925. *Psorophora ciliata* were quite numerous and annoying at the marsh; however no stained specimens have been recovered to date.

Summarizing the data in table 1 it is noted that a striking correlation exists between the flight range of *Culex pipiens* and *Aedes vexans*. In fact, so far, evidence in table 1 shows the flight range of all five species might be the same.

Table 3.—Flight range of two species of mosquitoes.

Species	Per Cent of Stained Mosquitoes Recovered		
	1–5 mile zone	5–10 mile zone	10–15 mile zone
Aedes vexans	17	42	41
Culex pipiens	15	39	46

The remaining one-half of the mosquitoes taken in the New Jersey traps will be examined for color within the next two months.

Incidentally in the staining experiment of 1936 one *Aedes dorsalis* was found at a distance of seven miles from the point of staining. In a collection of mosquitoes taken at the marsh while staining operations were in progress specimens of dorsalis were identified. However they constituted only a small percentage of the mosquitoes emerging, most of which were *A. vexans*.—2-6-43.

The Dried Fruit Moth Breeding in Nests of the Mountain Carpenter Bee in California

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The so-called dried fruit moth, *Vitula serratilineella* Rag., which has been found breeding in dried fruit in the San Joaquin and Santa Clara valleys of California, has been previously recorded from the honeycomb of weak colonies of bees in British Columbia (Cockle 1920). A closely related species, *Vitula edmandsii* (Packard) was originally described from the nests of bumblebees in eastern United States, and subsequent writers have noted its common occurrence in this habitat (Linsley 1942). It has also been reported from honeybee combs in Colorado and Nebraska (Anon. 1932; Milum 1940).

For the past two or three years, the writer has been looking unsuccessfully for *Vitula serratilineella* in the nests of western bumblebees. However, on June 1, 1942, near Nippiniwasse, Madera County, California, the species was found breeding in the cells of the mountain carpenter bee, *Xylocopa orpifex*

Smith, in an old log of incense cedar, *Libocedrus decurrens*. The same series of cells was infested with the tenebrionid *Aphanotus brevicornis* Leconte and two species of dermestids, *Attagenus* sp. (*piceus*?), *Trogoderma* sp. (*ajax*?); and it was therefore not possible to determine with certainty just what the moths were feeding on. However, the indications were that they had fed on pollen. A reared adult was sent to Mr. H. H. Keifer, of the State Department of Agriculture, Sacramento, California, who very kindly confirmed the writer's identification of the species.—10-21-42.

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Injury to Leaves of Sweet Corn by the Leafhopper *Dikraneura carneola* (Stal)[1]

G. W. BARBER, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The leafhopper *Dikraneura carneola* Stål was observed, from the middle of July to the last of September 1942, attacking sweet-corn plants in seed-production fields in Canyon County, Idaho, in the Snake River Valley. Specimens were first observed on July 16 in a field bordering the desert. At this time only adults were present, and they occurred

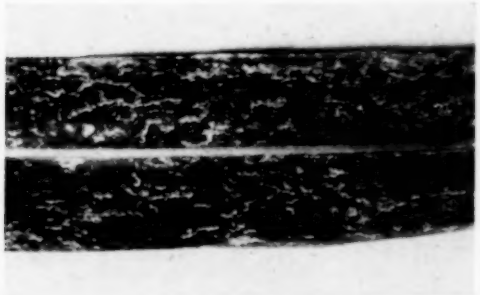

FIG. 1.—Injury caused by feeding the *Dikraneura carneola* to a leaf, 1.37 inches wide, of hybrid Country Gentleman sweet corn.

only at the edge of the field next the desert, although in large numbers. A week later they had become generally distributed through the field. As the season advanced they were observed in many but not all fields of seed sweet corn grown in the vicinity. When first observed, the concentration of large numbers in one edge of the field indicated that the insects had migrated recently to it, probably in a massed flight, for, although the field had been observed daily previous to July 16, the leafhoppers had not been seen before that date.

The injury caused by this insect is shown in figure 1. It consists of light, irregular blotches that are conspicuous on the leaves. Injury was particularly prevalent to the leaves of small plants or to the lower leaves of large plants. Apparently no plant disease was involved. Damage to the smaller plants probably resulted in interference with nutrition and a consequent reduction in the crop of seed produced. —11-28-42.

[1] Determined by P. W. Oman, Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

The Cork Oak Cynipid in California

E. O. ESSIG, *University of California, Berkeley*

Due to the scarcity of cork importations during the last few years a growing interest in the production of this product in this country is showing a steady increase. In California Professor Woodbridge Metcalf, Specialist in Agriculture Extension, has conducted a survey of cork oaks growing in this state and estimates that there are between 2000 and 4000 trees. Many of these have yielded considerable commercial cork. In this survey the work of the cork oak cynipid, *Plagiotrochus suberi* Weld, has been quite conspicuous and to some extent injurious in many sectors. This species infests the smaller twigs, making its galls within the tissues just beneath the bark. The infested twigs may or may not be swollen due to the presence of the galls. It was described by Weld (1926) from specimens collected on cork oak, *Quercus suber* L., at the Cottage City Nursery Co., north of San Jose and at Pasadena, California. During the past two years Metcalf has found the cork oak growing throughout much of California from the southern part of San Diego County in the south to Southern Humboldt County in the north. Many of the trees are isolated specimens. The cynipid which occurs throughout much of the state has been observed to be most abundant and injurious in southern California in parts of Los Angeles, Riverside, and San Bernardino counties, but is also quite plentiful as well as destructive in Napa and Sonoma counties and other areas of the San Francisco Bay Region, but has not yet been taken in the largest single planting of cork oak trees in California at Chico, Butte County. In many cases the insect kills an abundance of the young small twigs and may be a factor of considerable importance in reducing the production of cork. Observations up to the present time indicate that nearly all of the older cork oak trees are infested to some extent, even many of the wholly isolated ones. The young trees are usually free or relatively free from the cynipid and in some instances appear to be more or less immune for 10 or 15 years or more.

Since the cork trees are native to southern Europe and northern Africa and since most of the California specimens appear to have been grown from acorns it is somewhat difficult to explain the wide distribution of the cynipid and the infestation of the isolated trees which are often fifty or more miles from other cork oaks. While no records are so far known of young trees having been introduced into this state, it is possible that in earlier days nursery stock may have been sent in from Europe or from other parts of this country. But even this does not explain the many infested isolated trees that are positively

known to have been reared from acorns. Weld (1926) thought that it might possibly be a native California species, but Kinsey (1935) believes it to be certainly introduced.

Control measures consist in cutting out and burning the infested twigs and in giving the trees as good care as practical to insure vigorous new growth.

H. J. Ryan (1928) observed this insect to be quite injurious to cork oaks in Los Angeles County in 1927 and remarks that it has been in the state for many years.

My material was identified through the kindness of Dr. A. C. Kinsey, who has published a note on the economics of this insect in California (1935).—12-8-42.

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Survival Periods for Eggs of *Anastrepha ludens* (Loew) During Vapor-Heat Sterilization

EDWARD W. BAKER, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Because of the results obtained with infested fruit subjected to vapor-heat sterilization, eggs of the Mexican fruitfly, *Anastrepha ludens* (Loew), have been considered to be less resistant than the larvae. Incubation studies have strengthened this assumption. However, since some question has arisen concerning the viability of fruitfly eggs during this treatment, it was thought best to determine definitely whether eggs are less resistant than larvae. The chart pattern used with a variable-temperature instrument (Stone 1939) in the vapor-heat sterilization of infested fruits, giving a gradual approach period of 8 hours and an exposure period of 6 hours at 43.3° C., was used in the present studies.

Hollowed-out sections of mango skin[1] were used to obtain eggs, since the flies oviposit through the skin and the eggs can be picked off the ventral surface. To prevent fungus growth, the undersides of the skin sections were washed with 1:1,000 cupric chloride solution (Darby & Kapp 1933) before being paraffined to small glass plates. To simulate as closely as possible conditions in whole fruits, the eggs were kept in the skin sections until removed from the sterilization cabinet. At intervals during the sterilization several sections were removed and eggs were taken from the sections, placed on blackened filter paper moistened with cupric chloride solution, and allowed to incubate in stender dishes. Since preliminary work had shown that the effect of the rising temperature was not evident until the end of the third hour, eggs were not removed until then. From that period on eggs were removed hourly.

Hatch was obtained throughout the approach period (Table 1). In 1941 one egg hatched at the end of the eighth-hour approach period, whereas in 1942 there was no indication of development at this exposure. Apparently the eggs laid in 1941 were slightly more resistant. No sign of larval development was seen in the eggs removed during the exposure period.

In the past, infested fruits have been sterilized under the same conditions with larval survival through the first 3 hours of the exposure period and similar results have been obtained with naked larvae in petri dishes. Without doubt any vapor-heat treatment that will kill the larvae will also kill the eggs.—12-12-42.

[1] Keck, C. B. Technique used in biological research with the Mediterranean fruit fly. Fla. Mediterranean Fruit Fly Res. Rpt. 72 to U. S. Bur. Ent. Plant Quar., 22 pp., illus. May 5, 1930. [unpublished.]

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Table 1.—Effect of vapor-heat sterilization on eggs of Anastrepha ludens removed at hourly intervals during the approach period.

Hour of Removal	Average Temperature at Time of Removal °C.	1941		1942			
				Run 1		Run 2	
		Number of Eggs	Per Cent Hatch	Number of Eggs	Per Cent Hatch	Number of Eggs	Per Cent Hatch
Control	—	245	70.2	293	80.3	371	76.5
Start	20.3	—	—	—	—	—	—
First	27.8	—	—	—	—	—	—
Second	33.1	—	—	—	—	—	—
Third	36.9	245	73.1	290	77.2	303	86.8
Fourth	39.6	245	75.9	318	77.0	297	70.4
Fifth	41.3	245	64.5	225	71.6	384	61.9
Sixth	42.2	245	32.7	209	20.6	333	16.5
Seventh	42.6	245	9.8	500	0	300	0[1]
Eighth	43.3	245	.4	—	—	—	—

[1] One larva formed, but it did not emerge from the eggshell.

Some Fumigants of the Nitroparaffin Group

H. D. YOUNG and R. T. COTTON, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Nitroparaffins and their derivatives have until recently received little attention by entomologists, although chloropicrin, a member of this group, has been known as a useful fumigant for a number of years. Recently O'Kane & Smith (1941) have called attention to the insecticidal properties of another member of this group, 1,1-dichloro-1-nitroethane. Laboratory tests of four additional nitroparaffins have been made to determine their value as grain fumigants in comparison with 1,1-dichloro-1-nitroethane. The physical constants of these nitroparaffins are given below:

COMPOUND	MOLECULAR WEIGHT	SPECIFC GRAVITY AT 15°/15° C.	BOILING POINT, °C.
Nitromethane (CH_3NO_2)	61.04	1.364	101
Nitroethane ($CH_3NO_2CH_2$)	75.07	1.0547	115
1-Nitropropane ($CH_3NO_2CH_2CH_3$)	89.09	1.0041	131
2-Nitropropane ($CH_3CHNO_2CH_3$)	89.09	0.9973	118
1,1-Dichloro-1-nitroethane ($CH_3CCl_2NO_2$)	143.97	1.405[1]	122–125

[1] At 20°/20°C.

The insecticidal values of these compounds were compared by determining the dosages required to give 100-per cent kill of rice weevil, *Sitophilus oryza*, adults in 24 hours in the presence of wheat. The exposure chamber was a 20-liter glass bottle containing a half-bushel of wheat. All tests were conducted at approximately 75° F. Five lots of 30 adult weevils were used in each test.

With the exception of nitromethane, which did not give a kill with 18 cc. per half-bushel of grain, the following dosages of the various compounds were required to give 100-per cent kill:

COMPOUND	CUBIC CENTIMETERS PER HALF-BUSHEL	POUNDS PER 1000 BUSHELS
1,1-Dichloro-1-nitroethane	0.6	4
Nitroethane	5	23
2-Nitropropane	7	31
1-Nitropropane	8	35

According to Machle *et al.* (1940), the nitroparaffins that are liquid at ordinary temperatures have a pungent, chloroform-like odor not unlike that of a mixture of chloroform and diethyl ether. Nitroparaffins are toxic to warm-blooded animals, and precautions are necessary for their safe handling. Concentrations of 0.05 per cent by volume of nitromethane and nitroethane in air were found safe and tolerable for guinea pigs, rabbits, and monkeys, but 0.1 per cent by volume of nitromethane caused the death of one monkey and is therefore assumed to be a dangerous concentration for man. The toxicity appears to increase with the molecular weight of the compound.

Baking and milling tests made by cereal chemists of wheat treated with 1,1-dichloro-1-nitroethane indicate that the only noticeable effect on the baking characteristics was a reduction in the fermentation tolerance, *i.e.*, the range of time in fermentation over which good bread could be produced.—12-3-42.

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A Gas-tight Fabric for Fumigation Purposes

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An effort has been made for many years to secure a satisfactory gas-tight fabric for the fumigation of citrus trees. The requirements in field fumigation for such a fabric are exacting and have not been met by the various types of treated cloth that were tried in the past. These requirements include lightness, flexibility, and durability as to weathering, wear and tear, and retention of gas-tightness.

Samples of the synthetic product (*Koroseal*) were received in January, 1941, and exposed to the weather on the sun deck of a building. After six months of weathering with no deterioration, enough of the material was secured to make a 40-foot fumigation tent. This tent has been used for two fumigating seasons and is still satisfactory. An additional 45-foot tent has been in use during the past year. A reduction of two thirds of the fumigant (HCN) under the *Koroseal* tent gave a kill of the California red scale equal to that of the full dosage under an 8-ounce U. S. Army duck tent. Tests have shown that the material is very resistant to the attacks of mildew and a year's exposure to southern California sun has affected it but little.

Further experience with such a treated fabric is necessary as regards the fumigation of citrus trees under field conditions. The purpose of this note is to call to the attention of those interested a material that should prove satisfactory for use as a covering for general fumigating purposes. Such a synthetic material as described has gone a long way to overcome many of the objections to rubberized fabrics.—12-7-42.

The Spelling of Scientific Names of Some Stored Food Products Pests

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Herrick & Griswold (1933) have called attention to the fact that under the International Rules of Zoological Nomenclature the trivial name of the webbing clothes moth should be spelled "*bisselliella*." This spelling now appears in the official list of names approved by the American Association of Economic Entomologists (Muesebeck, 1942), although the incorrect "*biselliella*" still appears in recent literature with great frequency. Similarly, the trivial name of

the Mediterranean flour moth is "*kühniella*,"[1] although it is more commonly written "*kuehniella*" and appears thus in the official list. Further spelling variations are evident in the generic names of the lesser grain borer and flat grain beetles. The proper name for the former is "*Rhyzopertha*" (Stephens, 1830: 354; type: *Synodendron pusillum* Fabr., 1798, =*S. dominicum* Fabr., 1792), not the more usual "*Rhizopertha*" as emended by Agassiz (1846: 142). The generic name of the flat grain beetles is variously spelled "*Laemophloeus*" and "*Loemophloeus*." Most authors use the former spelling but credit the name to Castelnau (1850: 384; type: *Cucujus monilis* Fabr., 1877), who first characterized the genus. Actually, Castelnau used the second spelling and if the genus is credited to him the original spelling must be followed. The earliest use of the name, however, appears to be that of Dejean (1837: 340) who proposed it in his catalogue, unaccompanied by any description. Barber & Bridwell (1940) have recently summarized arguments in favor of the recognition of Dejean catalogue names, where known species were included in the genera. The present writer is in full accord with this procedure and in this case it will permit the more familiar spelling "*Laemophloeus*" to be retained.—11-21-42

[1] Article 19 of the International Rules of Zoological Nomenclature states "The original orthography of a name is to be preserved unless an error of transcription, a *lapsus calami*, or a typographical error is evident"; Article 20 adds "In forming names derived from languages in which the Latin alphabet is used, the exact original spelling, including diacritic marks, is to be retained."

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The Freezing of Insects—A Criticism and Explanation[1]

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and
G. ALLEN MAIL, *Dominion Livestock Insect Laboratory, Kamloops, B. C.*

The August 1942 issue of the JOURNAL contained a paper by G. Allen Mail (1942) dealing with lethal temperatures for certain ticks found in British Columbia. The section dealing with lethal low temperatures was based on a study of undercooling and rebound points. It is unfortunate that in that paper the observed rebound points were considered close enough for all practical purposes to the freezing points to be referred to as the freezing points. It is the purpose of this criticism to point out that such a concept is erroneous, and that in the paper the discrepancy amounted to as much as 25 Centigrade degrees.

The error was a common one in literature previous to 1936. In that year, Salt (1936) published the results of investigations which changed the entire concept of insect freezing, showing among other things that the rebound points of freezing insects are not related in any way to the true freezing points, but are essentially meaningless. If a dry thermocouple be placed alongside a dry insect and the system cooled below 0° C., the insect will undercool, much the same as other aqueous systems can be made to undercool. The extent of undercooling varies in insects from a few degrees to as much as 40 or 50 Centigrade degrees. When the insect undercools to its limit under the circumstances freezing suddenly begins and the liberation of heat of fusion causes a rise in temperature. The lowest temperature to which the insect undercools is called the undercooling point, and the rise in temperature is called the rebound. The latter is at first very rapid, but it gradually slows down until, only a few seconds at most after the undercooling point is reached, the temperature reaches a maximum, called the rebound point. The temperature may remain at the rebound point a short time or begin to fall again almost immediately, depending mainly on the size of the insect, or more exactly, on the amount of water it contains. It was the custom of earlier workers to consider the rebound point as practically synonymous with the freezing point, a correction by means of the formula $\Delta = \Delta' - 0.0125u\Delta'$ being all that was necessary to convert the rebound point to the true freezing point. As this correction is small in this type of work, within the limits of experimental error, it has usually been ignored as negligible and the observed rebound point referred to as the freezing point. For accurate results, however, the correction should be made.

It can be readily shown that the rebound point is not what it was considered to be in earlier papers and in the paper under discussion. When heat of fusion is given off in the body of a freezing insect or tick, it is insufficient to raise the temperature of the whole specimen to its true freezing point because the surroundings absorb too much of it. In an ideal albeit impossible system all of the heat would be absorbed by the aqueous parts of the specimen, and these parts would reach a temperature which, when corrected by the above formula, would become the true freezing point. However, the immediate surroundings, the thermocouple, its holder, and even the non-freezing parts of the insect itself, all absorb some of this heat. There is simply too much non-freezing surface area (immediate environment) in proportion to the source of heat (water content). The course of events when an insect reaches its undercooling point and starts to freeze parallels the fate of the heat of fusion. The latter is first greater than, then equal to, then less than the extraction of heat by the environment—this produces first the rebound or rise, then the rebound point or halt, then the subsequent fall in temperature. The rebound point, therefore, is merely the point at which the supply of heat from within and the demands from without are in temporary equilibrium.

Contention that the rebound point and the freezing point are not closely connected does not, however, locate the freezing point. This can be done in-

[1] Contribution No. 2208, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

directly, as was done by Salt (1936), by determining the melting point, which in an aqueous system is the same as the freezing point. The determination of the melting temperature is not quite as precise as the determination of the undercooling and rebound points, due to lack of a simple technique, but this will undoubtedly be remedied by future workers. The melting point can, however, be determined within one degree Centigrade for a soft-bodied insect by prodding it at intervals as the frozen specimen is warmed. The change from physical hardness to softness was shown by Salt (1936) to indicate melting of ice and not the melting or softening of fats. So far, no method of determining the melting points of hard-bodied insects without macerating them or piercing them with the thermocouple has been published. Maceration of sufficient specimens to give a sample of, for example, one cubic centimeter or more, was suggested by Salt (1936). This, however, precludes the determination of freezing points of individuals; it also precludes determining the undercooling points of the same individuals unless this is done before maceration. It is important to note in this connection that when an insect is pierced by the thermocouple or wounded in any way, the extent of undercooling is reduced. The rebound point is correspondingly raised, but this is of no importance. The true freezing point is not affected by such injury, while the undercooling point is definitely raised. The exact reason for the lessening of undercooling is not fully known, but two contributing factors should be mentioned. First, the degree of undercooling of water varies with the state of subdivision of that water. For example, water in bulk undercools but a few degrees; in an emulsion, more. In insect tissue it undercools from a few to 40 or 50 degrees; subdivided as a fog it has been undercooled to −155° C. (Kistler 1936). Natural fogs at temperatures of −25 to −50° C. are common (Kistler 1936). It therefore seems likely that liquid exuding at a wound acts as bulk water, and raises the undercooling point. The freezing of this liquid then seeds or inoculates the other body liquids, preventing undercooling by them to lower temperatures. A second contributing factor is the metallic thermocouple, which may form a nucleus of crystal formation when placed within a tissue, but not when placed merely in contact with the undamaged surface of the specimen.

On the basis of the above discussion the "freezing points" (rebound points) given by Mail (1942) are admitted by him to be inaccurate. He stated, for example, that a freezing point of −28° C. was recorded for eggs of *Dermacentor andersoni*. Their true freezing point was probably 25 degrees above this. Mail further stated that these eggs when macerated froze at −8° C. This latter figure, while still an erroneous rebound point, is much nearer to the true freezing point.

It is the hope of the authors that the foregoing discussion of the salient features of freezing in insects will serve to guide present and future workers on this subject and assist in forestalling further misinterpretations. Most of it is contained in one form or another in a technical bulletin by Salt (1936) and corroborated in part at least by later writers such as Ditman *et al.* (1942). It is to be hoped that research along this line will be pressed, for its practical bearing on insect control in temperate climates is immense. Before any great practical results can be expected, however, some of the fundamental concepts are in need of clarification. The changes occurring in undercooling, the action of contact moisture in reducing or eliminating undercooling, and the development of a technique to determine freezing points accurately are suggested as fundamental to further work.—12-8-42.

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Horsefly Control Incidental to Mosquito Control

HORACE O. LUND, *Naval Air Station, Elizabeth City, N. C.*

It is common knowledge that horseflies may be trapped in the surface film on oil-covered pools of water. Examples of how this control of horseflies may be accomplished purely incidentally in the process of controlling malaria-carrying mosquitoes were observed on September 25 and 26, 1942, near Elizabeth City, N. C.

In a 15-foot length of 3-foot woods ditch, sprayed with a thin layer of #2 fuel oil several days previously to kill mosquito larvae, 28 tabanids were dipped up, approximately one-half of which were females At the time of this observation, (about 3:00 P.M., E.W.T.) several horseflies were seen to dip into the water and then fly off.

On the following day, 184 tabanids were collected from a small alga-filled pool, 8 feet by 4 feet and about 6 inches deep, on the edge of a clean pine woods. In this case, 46 flies in a sample of 50 were males.

The flies were identified by Dr. Alan Stone of the U. S. Bureau of Entomology as *Tabanus sulcifrons* Macq. and *T. giganteus* Deg.—2-12-42.

Mr. T. T. Haack of Columbus, Ohio, has gone to Brazil where he will act as Principal Food Production Officer in the Institute of Inter-American Affairs. Mr. Haack's new address will be in care of the U. S. Consulate, Belém, Para, Brazil.

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Insect Pest Survey

CROP-INSECT CONTROL will not win the war. It is, however, of vital military importance to control mosquitoes, fleas, lice, and the like, which spread such dire epidemics among human beings as bubonic plague, yellow fever, malaria, and ship fever. It is said that the great Greek civilization of the early centuries was nearly destroyed by malaria and that Napoleon was defeated in Russia by a louse. But crop pests do very materially affect food production and, as an army "moves on its stomach," their control is undoubtedly of major importance in the all-out war effort.

In any strategic move, "to be forewarned is to be forearmed," and any means of knowing of probable insect depredations in advance gives the entomologists a decided advantage in the fight they must wage. It is impossible for any one State worker in entomology to know the insect problems that may arise in relation to all the crops in his State and in all parts of the State. Therefore a broad insect survey is necessary.

The object of an insect-pest survey is to organize the entomologists as a whole to act as a single body. The reports of certain insect damage in parts of one State indicate clearly that similar damage may occur in the adjoining parts of another State. Early appearance or unusual numbers of corn earworms in the early trucking areas of the South warn growers of sweet corn in the more northern sections that it will be necessary to protect their crops. The early appearance of the leafworm in the lower Rio Grande Valley is a warning to the cotton growers of the main Cotton Belt that they may expect this insect early enough to reduce cotton yields, if it is uncontrolled, and even warns the fruit growers of the Northern States that they may expect damage to soft-skinned fruits by the moths of these worms when they make their northward flights.

Beet leafhopper populations in parts of Arizona are an indication of possible heavy infestations northward in the Great Basin. The report of heavy overwintering of plum curculios in the Georgia Peach Belt indicates to peach growers farther north that they should be on the lookout for this pest and be prepared for early control. Armyworm outbreaks in any locality indicate that similar outbreaks may occur over a wide area. High populations of the pea aphid in the early-trucking sections near Norfolk, Va., are an indication that this insect must be watched for on the Eastern Shore of Maryland and in New Jersey, and high winter survival of the boll weevil indicates that, with favorable weather conditions during the growing season, the cotton crop may be seriously damaged.

Another object of insect-pest survey is to collect detailed information on the occurrence, distribution, ecology, and relative abundance of insect pests, and to study these data from month to month and from year to year with relation to the several factors that influence abundance. This is the necessary foundation for any advancement toward the possibility of relatively long-time entomological forecasting and should throw light on the causes of cyclic and sporadic appearances of insect pests, the gradual shift of regions of destructive abundance, the barriers to normal dispersal, and the directive influences that determine the paths of insect diffusion.

In the present emergency it is even more important that every effort be exerted to make the existing services more complete, and entomologists should consider it their duty to keep State and Federal survey workers as completely informed as possible.

At the suggestion of the American Association of Economic Entomologists, a national Insect Pest Survey, under the direction of the Bureau of Entomology,

and later under the Bureau of Entomology and Plant Quarantine, was initiated 21 years ago. The Survey has functioned continuously since that time and, although practically eliminated by recent Congressional action, is still serving in a very limited way with the funds available. In the past more than 300 entomologists located in every State in the Union have acted as collaborators, and the most extensive collection of insect-pest data ever assembled on the continent has been amassed. The Survey now has over 400,000 notes on approximately 50,000 species of insects. These data have been and still are available to all working entomologists and in innumerable cases have led to great savings, both in the use of insecticides and in the avoidance of crop losses.

So much for past accomplishments. Now, how may this service be improved when the war is over? First, by an improvement in the method of reporting, so that the data collected will be sufficiently complete to have statistical significance. This of course means that a great deal of research work must be done on adequate sampling. Second, laboratories should be established in at least six most distinctive crop regions—the Northwest, the Southwest, the Great Plains, the Southeast, the East Central States, and the Northeastern States. These laboratories should be equipped first of all with an entomologist who has a broad training in general taxonomy and biometrics and some experience in survey work. If possible, there should be an assistant to aid in making collections and counts. The regional laboratories should cooperate with the States and other workers within the region, and their work would be immensely facilitated if each could have a portable laboratory, such as has been used during the last few years in phony peach and peach mosaic surveys. These portable laboratories would make possible a complete coverage of the regions studied and a detailed mapping of the life zones. The staffs of the regional laboratories could then outline the desired data to be collected by the collaborators at fixed stations and we would be on the way to insect forecasting. And economic entomology in the United States would move into a new period.—11-21-42.

J. A. HYSLOP

Entomology in 1943

THE CHAIRMAN of the Committee on "The Coordination of Entomology with the War Effort," in his latest report, has very properly pointed out that it is the part of good sense for us to consider clearly the possibility of a war which may last for five years or even longer and then permanent plans which visualize a short war will have no certainty of meeting the needs of the situation with which we may be confronted. Certainly there can be but few who do not heartily endorse the wisdom of this stand.

At the same time it must be evident that the problems must be met, not all at once for a five-year period, but year by year, as the problems materialize, they must be solved. And that the first step in the five-year task is the solution of the problems of 1943, not forgetting those of later years but concentrating immediately on current problems.

That the task of the entomological profession would be extensive and difficult was recognized early by the entomologists. In order that this task might be accomplished steps were taken early to insure the greatest possible degree of cooperation. The shortage of certain insecticides, difficulties of transportation, new food-production goals and many other factors rendered necessary the revision of many of our insect control recommendations. For each entomologist to revise recommendations for all the pests with which he must be concerned, in time for immediate effect, would have been a virtually impossible task. For this reason the Committee mentioned organized voluntary sub-committees, each of which was to perform this task for a certain crop or crop-group and for a restricted region. This developed into an extensive cooperative enterprise. Leaders for each sub-project were nominated by the committee and these leaders chose their own associates. A roster of the persons concerned was published in connection with the first report of the committee and to the cooperation of the persons there named is due the credit of the

accomplishments of all these committees.

The basic task of each sub-committee was to accumulate information and to formulate recommendations, based on the emergency conditions under which we must work, which should most effectively aid in the control of the insect pests of the important crops. This done, the information was to be made available for the free use of all entomologists concerned with those crops.

The sub-committees have been very active and the fruits of their labors are now becoming available in the shape of concise and practical summaries of recommended control practices. Some of these have already been distributed; others may be expected in the near future. Entomologists generally must be convinced that the sub-committees have done their job well.

Entomologists must also recognize the fact that the sub-committees can not complete the task which is to place the information in the hands of every possible user and to make every effort to see that such persons actually do make use of the information. Only when this is done has the entomological profession approximated the minimum which should be expected and even demanded of it. Entomologists are therefore urged to examine the committee reports as they are received; to modify the reports to fit their local conditions, if that seems desirable, and to arrange for the widest possible distribution of the material.

The original committee has devoted some time to the study of the problem and to the organization of the sub-committees. But it is the sub-committees who have done the greater part of the actual work. Our Association many years ago, unofficially adopted a slogan—"Credit where credit is due." In this case credit is surely due the project leaders, serving as chairmen of the various sub-committees, and to the personnel of the sub-committees. No better method of recognizing the value of this work and indicating appreciation than that of full utilization of the results can be suggested.—2-8-43.

OBITUARIES

Lester E. Gibson 1889-1942

On November 14, 1942 Mr. Lester E. Gibson who was employed by the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, on the gypsy moth project died at his home in Greenfield, Massachusetts.

He was born February 24, 1889, graduated from the Melrose, Massachusetts high school in 1908 and from the Massachusetts Agricultural College in 1912 with the degree of B.S. His major work was in pomology and plant pathology and his minors in entomology and forestry.

After graduation he was employed by the Great Northern Paper Company during the summer and fall of that year and carried on field work on some of their holdings in the state of Maine. On June 20, 1913 he was employed as a scout on the Federal gypsy moth work and later assisted in laying out and recording data on silvicultural plots which were established for the purpose of securing useful data relative to the application of silvicultural principles to forest areas infested with the gypsy moth. He was promoted from time to time, continued on general field work and at the time of his death held the position of Senior Administrative Assistant.

Mr. Gibson was well versed in managing the field work and was also responsible for the plans which built up an orderly arrangement of the stock and materials which were used in the field as well as in the office and storehouse. He was very efficient and of a genial disposition which endeared him to the people with whom he came in contact, in spite of the fact that his health was such at times that he

experienced continued and prolonged suffering. He was a member of Wyoming Lodge of Masons at Melrose, Massachusetts, and Kappa Sigma fraternity of Massachusetts State College.

He leaves a father and mother, a wife and two daughters. Funeral services were held at Greenfield and interment at Wyoming Cemetery in Melrose where a short service was performed. Mr. Gibson was held in high esteem by his associates on the gypsy moth work and by the public in general and individuals with whom he came in contact.—11-27-42.

A. F. BURGESS
Greenfield, Mass.

Rennie Wilbur Doane, 1871-1942

Rennie Wilbur Doane, Emeritus Professor of Entomology at Stanford and a member of the pioneer class at the University, died at his home on the campus on December 1, 1942. He was graduated in entomology in 1896 having studied under such able men as Professors Comstock and Kellogg.

The same year Professor Doane then became Assistant Zoologist and Entomologist in what is now the Washington State College at Pullman and later was made Assistant Professor. In 1900 he became interested in propagating eastern oysters on the Pacific coast, and in 1901 was appointed superintendent of the Fisheries Experiment Station at Keyport, Washington, Here he carried on experiments dealing with fishing problems. In 1905 he returned to Stanford as Assistant in Entomology where he taught until his retirement as Professor of Biology in 1936.

Professor Doane played a very important part in the development of economic entomology. In 1908 he was called to the Society Islands to study a scale insect that was destroying the coconut plants there and he succeeded in distributing a parasite that soon controlled the pest. His battle against a beetle took place in 1913 in the Samoan Islands where he again rescued the coconuts. In many states he made studies of industrial plants to determine the damage due to insect pests and plant diseases. During the war he served as Consulting Entomologist for the California Food Commission and as collaborator with with the United States Bureau of Entomology. For many years Professor Doane was chairman of the Matadero Mosquito Abatement District and did much work as consultant on the subject of injuries resulting from smelter smoke.

His writings include articles in scientific journals dealing with various insect pests and Experiment Station bulletins. *Insect Pests* published in 1910 went into an English and a Swedish edition. His most recent book *Forest Insects* was written in collaboration with E. C. Van Dyke, W. F. Chamberlin and H. E. Burke.

Professor Doane will long be remembered among his associates as a devoted teacher and a kindly gentleman. His writings and accomplishments are invaluable to students of research in economic entomology.

Professor Doane was born in Des Moines, Iowa, in 1871. He is survived by his wife, Mrs. Elnora Cooper Doane, a son, Donald, one sister and one brother.

C. J. PIERSON
January 20, 1943

REVIEW

The Genus *Conotrachelus* Dejean in the North Central United States, by Herbert Frederick Schoof, 170 pp. ix plates. The University of Illinois Press, Urbana, Illinois, 1942.

Taxonomists and students of economic problems alike should welcome this contribution from the Entomological Laboratories of the University of Illinois which reports the results of an intensive investigation of the relationships of the species of *Conotrachelus* to be found in Illinois and the adjacent states, Wisconsin, Iowa, Missouri, Kentucky and Indiana.

Dr. Schoof states the objective of the study to have been the construction of workable keys to, and descriptions of, the species occurring within the geographical limits indicated, to make certain morphological studies, particularly of the male genitalia, and to determine the taxonomic significance of these and other morphological features of the insects.

Since the majority of the species discussed occur rather generally over the eastern portions of the country, the scope of the work may be expected to be much greater than that indicated by the list of states mentioned. Methods used in the study are clearly indicated, previous work is carefully evaluated and discussed and the value of the several characters used in keys and descriptions is given thorough consideration. A discussion of the taxonomic status of the genus completes the introductory material. In this Dr. Schoof indicated that Dejean (1835) is properly to be considered as the author of the genus and cites what seem to be abundant reasons for this conclusion, in spite of the fact that Schönherr (1837) and Latrielle (1835) have both been listed in previous works as having established the genus.

The section on classification embraces 28 species including five which are new. These species are arranged in four groups and keys for their identification are constructed on this basis. Descriptions are supplemented by information on distribution, biology, phylogeny and nomenclature. A glossary appended will enable the user to grasp the exact sense in which various technical terms are used in the descriptions and keys.

Plates are clear cut and ample in size. They deal mainly with genitalia but include other structural features which need clarification.

Dr. Schoof is to be commended for an excellent piece of work and congratulated for having produced a work which should find its place among the little classics of taxonomy.—12-10-42.

COMMITTEE REPORTS

Report of the Committee on Coordination of Entomology with the War Effort: 1942

The two entomological organizations at their meetings in San Francisco, December, 1941, adopted a special joint resolution (Annals, Ent. Soc. Am., 35(1): 133: Jour. Econ. Ent., 35(1): 132) as evidence of a patriotic determination of the members to direct the professional efforts of entomologists into lines of maximum usefulness to the government and people of the nation in a period of unprecedented crisis. The resolution expressed the consciousness of members of the entomological profession of an unquestioned need for constructive leadership and for unified effort, and to attain these essential ends, the resolution specified certain steps which it seemed desirable to take at the earliest practicable moment.

Acting on the recommendations made to him in this resolution, the Chief of the Bureau of Entomology and Plant Quarantine on January 31, 1942 communicated with various leaders in entomology relative to the holding of a special conference to institute and work toward the indicated objectives. The replies received apparently did not indicate that a fairly representative attendance might be expected, inasmuch as he (March 5) asked the presidents of the two entomological organizations to designate a committee to confer with him. Acting on this suggestion, President Weiss of the American Association of Economic Entomologists named Messrs. F. L. Campbell and C. H. Richardson.

Messrs. Campbell and Richardson conferred with the Chief of the Bureau of Entomology and Plant Quarantine and with others, and indicated one line of action as immediately important. They recommended the appointment of a Joint Committee of the American Association of Economic Entomologists and the Entomological Society of America to act in a liaison capacity between civilian entomologists and the military services. They suggested a plan of acquiring information on entomological personnel and other matters which would help to bring about further professional utilization of entomologists in the military services. The committee appointed by the two societies consists of Messrs. Ernest N. Cory, Robert Matheson and F. C. Bishopp, *Chairman*.

At the San Francisco meeting, the American Association of Economic Entomologists authorized the appointment of a committee to work with manufacturers of insecticides and with governmental agencies concerned with priorities of such materials, and to keep entomologists informed regarding changes in the availability of insecticidal materials. This committee was formed by the appointment of Messrs. C. C. Hamilton, R. C. Roark and J.L. Horsfall, *Chairman*, designated as the *Committee on Insecticide Supplies*. The committee is functioning and is also cooperating with a similar committee concerned with fungicides. These two committees are unrelated to the Committee on Coordination of Entomology with the War Effort, and their appointment indicates why the latter Committee does not deal with these subjects.

In the opinion of President Weiss and others, the tasks of these two special committees failed to include the entire emergency effort contemplated in the joint resolution. On April 20, 1942, he appointed a Committee on Coordination of Entomology with the War Effort, consisting of Messrs. John S. Houser, L. M. Peairs, P. D. Sanders, Frank N. Wallace and E. F. Phillips, *Chairman*. On recommendation of the Committee, President Weiss invited the Chief of the Bureau of Entomology and Plant Quarantine to nominate a member of the administrative staff of the Bureau to take membership on the Committee, and Avery S. Hoyt was so nominated and appointed. The Committee also recommended that the Secretary of the Association, Ernest N. Cory, be named on the Committee, and this was done. Subsequently the Entomological Society of America designated S. A. Graham as a representative of that organization on the Committee. The present Committee then consists of the eight persons named, of whom five are members of both organizations.

The originally appointed Committee met in College Park, Maryland, May 6 to 10. It reported to the Executive Committee, and this report was published in the April issue of the Journal of Economic Entomology, advising that coordinators be indicated for the control of the more important insect pests, to carry control recommendations to the "grass roots" as soon as possible.

After approval of the plan recommended by the Committee, and by arrangement of the entire Committee, Messrs. Cory, Sanders, Hoyt and Phillips met in Washington, June 10 to 12. Aided by heads of various divisions of the Bureau of Entomology and Plant Quarantine, they made a survey of the most important insect pests of those agricultural crops for which increased quotas had been established by the Secretary of Agriculture, and for each such insect pest or group of pests, a member of the Association was selected as a leader to head an attack on the problem of furnishing information on methods of control as quickly as possible to those on the firing line of production. To conduct these tasks, the Committee selected entomologists without regard to administrative affiliations, making the selections on the basis of qualifications and experience in conducting such undertakings. The Committee is well aware that it possesses no authority to make such assignments, but it is equally aware that entomologists are ready and willing to take on any extra task, if it gives promise of aiding the war effort.

There are still other problems for which an active emergency campaign would be helpful, and the Committee advised entomologists to set up their own plans for any of these. In at least one instance this is being done. In a few instances only did the Committee go beyond problems which pertain to increased crop quotas set by the Secretary of Agriculture. In cases in which the Committee knew that additional action was already under way it did not offer suggestions. The responses of entomologists have been in the affirmative, enthusiastic and heart-warming, and all the more satisfying at a time when members of the profession are called upon to carry an increased share of responsibility as citizens.

It would be futile to undertake an evaluation of an effort of this type. All that the Committee tried to do was to point out opportunities for service, leaving it to the leaders to select their own aids, to discover the most effective avenues through which to transmit the needed information and recommen-

dations. Doubtless opportunities have been overlooked, and perhaps some of the efforts may prove ineffective, but the Committee did its best to indicate important problems and to allocate them to entomologists well qualified for the extra tasks. It is hoped that delay and confusion in disseminating useful information has been avoided to a substantial degree.

It was planned that, at the annual meeting, periods would be set aside during which the men involved in the special problems considered by the Committee might have opportunity to get together for informal conference, and for the making of plans of attack for 1943. Time had been designated for the leaders of various problems to discuss the work under way. Inability to hold the annual meeting made these plans impossible to carry out, hence leaders of various projects have found it necessary to continue their work by correspondence. The methods of attack must differ, and in many cases the cooperation of the extension service or of some other organization would be helpful. Sometimes special publications, posters or some other material may be demanded, and at other times personal contacts are more vital than printed directions.

The Committee has published a list of special projects and the names of the men who seemed abundantly qualified to undertake the tasks. All of us hope that as a result of these requests for cooperation, an even more united attack may be made on our insect enemies at a time when insect pests must be considered as allies of the totalitarian powers. We have faith that those who have accepted these responsibilities will use their utmost efforts to carry to the actual users full available information on known control measures.

In discussing cooperative efforts among entomologists, it would be a gross oversight not to suggest briefly the extent to which such cooperation already exists. In its first report, the Committee indicated the existence of regional branch organizations and subject matter sections, in all of which men of allied entomological interest get together. Under the auspices of the Association of Economic Entomologists, men engaged in work on codling moth and other fruit insects of various areas, pea aphis, tobacco insects and the like, meet annually to exchange results, to stimulate each other by suggestions and criticisms and to set about the heavy task of making their efforts more useful. It is doubtful if, among men of any other branch of scientific work, there is better cooperation than already exists among entomologists. The national and regional Plant Boards are added instances of cooperation of this type, extended in these cases to include plant pathologists and men officially responsible in quarantine activities. All this cooperation, set up in days of peace, gave the Committee a feeling of assurance of hearty cooperation from entomologists when an opportunity is presented or can be discovered. In seeking to increase this cooperative endeavor, the Committee feels that it is best following out a primary intent of the joint resolution.

The Committee considers it important to make known to entomologists that the National Research Council has formed a Committee on Crop Protection, composed of plant pathologists and entomologists, under the chairmanship of Prof. E. C. STAKMAN, who is also chairman of the War Committee of the Phytopathological Society. This committee, consisting of J. G. LEACH, J. L. HORSFALL, J. G. HORSFALL, W. P. FLINT and E. F. PHILLIPS, met in Washington on October 15. This National Research Council committee presents a favorable means for developing even more cooperation between entomologists and plant pathologists. It seems appropriate also to state that the Phytopathological Society is well organized in the war effort.

The Committee recognizes that the curtailment of activities of the Insect Pest Survey issued by the Bureau of Entomology and Plant Quarantine has been a vital loss to services which entomology can render in the battle against insect enemies, and in the present emergency this loss is felt in exceptional degree. Since delay would make any appeal inconsequential, the Committee on October 17, 1942, addressed a letter to the Director of the Budget urging the re-establishment of the Survey in full. The Committee feels that this action will meet with universal approval of entomologists.

The Committee was specifically asked to consider a problem, important not only to entomology, but equally to other lines of work, the authorized reorganization of research in the Department of Agriculture. On December 13, 1941 the Secretary of Agriculture issued Memorandum No. 960 entitled "Organization of Department for War Effort." This memorandum begins as follows:

> "In order to increase to the fullest possible extent the contribution of the Department of Agriculture toward winning the war, I am reorganizing the Department's administrative machinery.
>
> "The seventeen line agencies that now report directly to the Secretary are being grouped for more effective action and coordination under the direction of eight group administrators.
>
> "I am establishing an Agricultural Defense Board composed of eleven Department officials.
>
> "Through this Board and the grouping of the line agencies, we hope to contribute our maximum effort to the primary responsibility of American agriculture during the emergency—the production of the food and fiber needed by this country and her allies.
>
> "To this task, all others must be subordinated.
>
> "I feel that the reorganization will enable the Offices of the Secretary, the Under-Secretary, and the Assistant Secretary to concentrate upon the production program and other vital wartime programs. I feel also that the changes will enable the Department to centralize responsibility for the execution of these programs; to center research activities of the Department upon war needs; to produce abundantly without soil waste and destruction; to move toward a reduction in the number of Department agencies in the field which farmers must contact; and to enable the Department to meet all increased duties and responsibilities with greater efficiency and economy."

The grouping of the 17 line agencies referred to in the foregoing quotation as it was carried out with respect to the Bureau of Entomology and Plant Quarantine is covered in a later paragraph which we quote:

> "During the first World War, the scientific research agencies of the Department made notable contributions to victory. We hope to see to it that these agencies are even more effective during this war. Therefore, I am grouping together the Bureau of Animal Industry, Bureau of Dairy Industry, Bureau of Plant Industry, Bureau of Agricultural Chemistry and Engineering, the Bureau of Entomology and Plant Quarantine, the

Bureau of Home Economics, the Office of Experiment Stations, and the Beltsville Research Center. These agencies will also retain their Bureau status, but their activities will be under the supervision and direction of an Administrator acting as my personal representative."

Secretary Memorandum No. 960 states with respect to the group administrators that:

"In the exercise of the authority vested in him by paragraph 1 of this memorandum, and in accordance with the applicable laws and regulations, the Administrator, or the Acting Administrator, shall, among other things, with respect to the agencies placed under his direction,

a. Direct and supervise their activities;
b. Direct and supervise the work of their officers and employees;
c. Delegate, in his discretion, his authority to their officers and employees;
d. Utilize their personnel, funds, property, and services; and
e. Consolidate or integrate their administrative, technical, staff, and other services."

Later, under date of February 24, 1942, Executive Order No. 9069 consolidated certain agencies within the Department of Agriculture, the grouping being along the lines indicated in Secretary's Memorandum No. 960. This was followed on February 25 by Secretary's Memorandum No. 986 entitled "Establishing Agencies of the Agricultural Research Administration." The Executive Order and Secretary's memoranda outline the authority of the Agricultural Research Administrator. Broad powers are granted to make such changes in organization as may be deemed necessary. Since the authority thus granted might permit reorganization of existing groups on a crop basis or on any other basis, desired by the Administrator, concern was felt for the future of entomology. The authority granted in the Executive Order remains "in force during the continuance of the present war and for 6 months after termination thereof," but there is no time limit or period of duration fixed in the memoranda issued by the Secretary of Agriculture to indicate a date of termination for the exercise of this authority.

A reason for concern arises from the fact that on previous occasions the integrity of the entomological work of the federal government has been threatened. In the late nineties a plan was proposed to reorganize all the work of the Department of Agriculture on a crop basis, but this plan was averted. Many entomologists will recall that in 1933 a committee on administrators within the Department was reportedly prepared to recommend organization on a crop basis. Before this plan was put into effect, a joint committee of the two entomological organizations made presentations to the Secretary of Agriculture which averted such action for entomology, but at that time certain other lines of scientific work were organized on a crop basis. These two instances in which efforts have been made to organize work on some basis other than that of the branch of scientific work involved, naturally cause entomologists to be concerned whenever changes in administration of scientific work in the Department of Agriculture are proposed or authorized. It then seemed important that inquiries be made. This was even more important because of other administrative changes already made in the organization of the Department.

On June 10, three members of the Committee interviewed the Secretary of Agriculture on this subject. They were assured that he had no knowledge of a plan to organize on a crop basis. Members of the Committee have been informed that the Administrator has stated that he had no intent of disrupting the existing bureaus or other organizations composing the Agricultural Research Administration. The Committee thinks it appropriate to express its gratification of this assurance of the continued status of the Bureau of Entomology and Plant Quarantine.

In view of the sweeping changes which have been made in the agencies of the Department by other group administrators, the Committee believes that so long as this authority remains unchanged, watchfulness on the part of entomologists is essential to avoid later interpretations of this memorandum. We should be on the alert for indications along the line of gradual encroachments in the administration of the Bureau and drastic reorganization plans or for the superimposing of administrative direction, which might not promote the best interests of entomological work.

Concern among entomologists with possible administrative changes rests on the eminence of the entomological work of the Department, which to entomologists is a matter of pardonable pride. The Bureau is the entomological capital of the world. In no country other than the United States has it been more imperative that effective control measures be found for insect pests. Importation of crop plants, development of specialized agriculture, changes of hosts of native species of insects and other changes in agriculture, especially since the Civil War, have made possible concentrations of insect populations, which unless curbed, would have dedicated far too much of our crops to the feeding of insects. The destruction caused by insects constitutes truly an enormous burden on citizens of the country. At a time when maximum crops are so important, losses from insects become still more vital, and entomologists know that even with the best control measures, losses remain too high. It has thus been necessary that under the federal government there be maintained a great fighting force to protect our economy from insect enemies. It is no surprise that federal work in entomology has risen to the top.

The war against the insects requires coordinated effort, and cooperative work has been developed between federal and state organizations, for widespread education as to the damage done by insects, in methods for their control, for unity of action, and more recently for the application of methods of adult education and for programs of eradication, all of which have made results of research more effective. The need of manpower has led to the growth of departments of entomology in various educational institutions often larger than departments in the broader field of zoology. Throughout this development, the Bureau retains a place of pre-eminence in almost every field except the training of entomologists which is outside its competence.

Inevitably in such a growth there have been occasions when differences of opinion have arisen between federal and state men, and sometimes questions of legal authority. Full harmony in so quickly developing a field would be evidence only of laxity. There is no reason for glossing over such situations, because, despite all occasions when policies of the Bureau have been questioned, all entomologists realize that from its strength, its strategic position and its manpower, the Bureau must be accorded first place in all the world in the battle against in-

sects. Entomologists grant to the Bureau this place, and desire to have that place maintained.

Not only has the Bureau provided leadership within the country, but its influence is world-wide. Entomologists of the Dominion of Canada have cooperated freely and have carried their full share of the load, in research and in methods of application. With Mexico and other lands of Ibero-America, partly because of our national policy of being good neighbors, but primarily independent of all political considerations, the Bureau cooperates to the benefit of all countries concerned. Only the work of the federal government could thus make itself felt all over the world. In a time of world-wide war, international cooperation is hampered, but the Bureau if unmolested, will later be prepared to renew its happy relationships with entomologists of the world. Probably no other American group in applied science has done more for international harmony than has the Bureau as the national representative of applied entomology. If the entomological work of the government had been organized on any basis other than that of the branch of science concerned, or if it had been merely a small unit in a huge over-all scientific administration, this committee believes such international cooperation could not have been developed.

The Committee advises that the effort undertaken by action of the President of the American Association of Economic Entomologists be considered as a preliminary step, that plans for future efforts be considered with great care, and that provision be made whereby cooperative efforts may be increased and so planned as to prepare the profession of entomology for its far heavier tasks of the near future. Tasks ahead are heavier than any so far faced, and unless entomology justifies its existence through enlightened initiation of services, it will utterly have failed in its great opportunity. In this entomology will not fail.

Hundreds of entomologists have discontinued their accustomed work to meet the obligations arising from the war, and many more will be called upon either to drop their usual work or to take on added duties. Probably most of us, for months and years to come, will find that the work which we prefer, and even the work for which we are best equipped, is not that which yields the best results in the war effort, and whatever changes in duties may be indicated will be accepted gladly. Not only must we accept new obligations when they are pointed out to us, but we must seek through combined strength to anticipate opportunities, to discover other ways to serve and to prepare ourselves and others for opportunities not yet made clear. The appointment of a committee as a sort of clearing house for such work should in no degree be considered a solution of the problem of adjusting entomology to the needs of the time. In searching for opportunities by which entomologists may be of service, we shall remember that entomology cannot be fully helpful until its usefulness is evident to persons other than entomologists. All these things we shall do in a determination that one day we shall regain the freedom to do those things in entomology which most appeal to us, freedom to plan our own lives and freedom to serve in ways which we consider best, which are only other ways of stating the freedoms for which all free men now fight. Nothing now is so important as the winning of the war, and to that high cause entomologists dedicate themselves.

Finally, the Committee wishes to point out that it is fully aware that it exists as the servant of the Association which established it, that it can function only in cooperation with the membership of the Association and that such cooperation, to be fully realized, must originate with the individual members of the Association. For this reason, suggestions are invited and will be given careful consideration; criticisms also are entirely in order at any time when they may seem justified.

Respectfully submitted,

ERNEST N. CORY — L. M. PEAIRS
S. A. GRAHAM — P. D. SANDERS
JOHN S. HOUSER — FRANK N. WALLACE
AVERY S. HOYT — E. F. PHILLIPS, *Chairman*

Report of the Committee on Coordination of Entomology with the War Effort

Meeting of February 5, 6 & 7, 1943
College Park, Maryland

The Committee met in College Park, Maryland, February 5 to 7, 1943, with Members Cory, Graham, Houser, Hoyt, Peairs and Phillips present. Unavoidable delay in the election of new officers of the two entomological organizations, and the time involved in their taking office made it seem necessary that the Committee meet, so that more specific suggestions might be made to the officers, and especially so that there might not be too great delay in inaugurating such added plans for 1943 as might be desirable.

In presenting further suggestions and plans to the entomological profession, the Committee must make the assumption that the war may not be of short duration. If one were to assume that the war will soon terminate, then it must also be assumed that there is no time for the profession to formulate extensive plans for modification of its activities in time for them to be useful and effective. Since there is scant reason to believe that the war will be short, the Committee makes these and all of its suggestions with the probability of a long conflict firmly in mind.

Since the cancellation of the winter meetings made it impossible for assigned leaders of the various projects for carrying available information to growers to confer and report their methods, the Committee requested each leader to submit a statement of methods followed and results obtained. The reports were carefully studied by the Committee and are highly gratifying.

A majority of project leaders have exceeded the expectations of the Committee. Some leaders have prepared effective material for publication and have arranged for publication, in some instances in fields not previously well covered. Most leaders have prepared brief but inclusive statements of pest control measures, with due recognition of differences in biological and cultural areas. These are ready to be issued for immediate use. Some have already distributed the prepared material to other entomologists. The Committee concludes after studying these reports that in some instances a considerable improvement in presentation has been made in outlining control measures, with excellent adjustments of the type made necessary by changed conditions due to the war.

The problem which seems most to have bothered project leaders is that of the final step of transmitting this important information to growers. No general rule could be laid down for this, but if entomology

is to render the greatest possible service, it is essential that project leaders assume responsibility for developing these plans. In order that leaders may be aided somewhat in their later efforts, the Committee makes the following general suggestions for a continuing and sustained drive toward the desired objectives:

1. That, if not already completed, brief, specific recommendations for the control of the different insect pests be written out in form suitable for other entomologists to use in preparing practical material for distribution, with such regional variations as the problems demand.

2. That in the material sent to other entomologists there be included *brief* reference to the most important, readily available publications on the subject.

3. That this material be mimeographed or otherwise duplicated for distribution to all entomologists who should be concerned in dissemination of control methods in that field.

4. That when this material is distributed, a note be inserted granting permission to utilize the recommendations in any manner which seems most expedient in each state or area, not overlooking the press, so that recipients of the material may not be in doubt as to their right to use it.

5. That the problem of printing or otherwise duplicating for use be left to the resourcefulness of those entomologists who should have use for such material.

6. That when any of the distributed material is used, notification be sent to the project leader, so that he may be aware of and have a record of the use made of the prepared material.

7. That until the information assembled has been placed in the hands of every possible user, the objective of the effort has not been attained.

8. That the indicated steps be taken promptly, since delay is likely to result in making the effort useless for the season of 1943.

Quotas established by the Secretary of Agriculture for increased production in 1943 differ somewhat from those of the previous year, and previously selected project leaders will be sent the revised quotas. Some new needs for widespread work on insect control arise from the quota changes, so the Committee has invited four additional entomologists to assume responsibility for carrying the most suitable methods of control to those actually engaged in growing the crops in question. These new leaders are as follows:

Flaxseed	A. G. RUGGLES
Rice	DWIGHT ISLEY
Naval Stores	F. C. CRAIGHEAD
Commercial Truck Crops	W. H. WHITE

The Committee recognizes the present increased need of prompt and adequate service in the identification of insects, not only as an aid to the Armed Forces at home and abroad, but for civilian use in executing pest control activities in the most effective manner. Correct diagnosis of the pest is the first step in planning an intelligent, economical control procedure under normal conditions. This is doubly important because of the possibility of losses from unexpected insect outbreaks in these abnormal times. This work must be centered in the section of the Bureau of Entomology and Plant Quarantine devoted to identification work, but current needs and an already reduced staff make added facilities necessary. The Committee suggests as one means of alleviating this situation that the Entomological Society of America be asked to circularize its membership and solicit their aid in this work, asking each member to indicate which groups he feels competent to handle. Because of the urgency of the work, each volunteer should agree to give prompt attention to the material submitted for identification.

The problem of manpower in entomology approaches the acute stage by reason of the inclusion of approximately 500 entomologists in the armed forces. The Committee on Military Entomology has functioned actively and effectively in the placement of many of those who have entered military services and should continue to serve in relation to that phase of the problem of manpower.

Entomologists ask no special favors or undue consideration. This Committee believes that it speaks for the profession in defining its attitude towards the entire manpower problem in entomology as follows:

The first concern of the two organizations, of this committee, and of every entomologist is the winning of the war. Each entomologist must decide, within the regulations set up by those having authority over the activities of the manpower of the nation, what his own duty may be and how he may best serve. If he feels that he can serve the needs of the country better by entering the armed forces, and his circumstances are such that he can do this, every effort will be made to help him get placed in the service where he will be of the greatest possible value, whether that be in entomological work or in some other capacity.

It is recognized that the immediate progress of the science of entomology may be greatly impeded by losses in personnel and by the necessity which may arise for the diversion of the time and efforts of entomologists outside the army to tasks which formerly either have not been important or have been cared for by men now in the army. This condition is accepted by the profession as an inevitable and necessary result of the war, and all entomologists not in the service are more than willing to assume extra duties, to devote a greater total effort than formerly to the entomological needs of the country, to change, temporarily, so much as may seem necessary, the character of the work done, from research to the supervision of the immediate application of entomological information already at hand and ready to be used, to a much greater extent than has ever been done. The training of entomologists for the future will have to be adjusted to the present situation.

Entomologists are willing to give their full attention, so far as possible, to the immediate problems of the nation, the problem of conservation of the products of agriculture, of other materials, of the health of man and animals, to the end that there will be no shortage which is due to uncontrolled insect activity.

Entomologists not available for military service are glad, therefore, to pledge themselves to all possible extra effort and to assume whatever burden may be imposed on the profession by force of circumstances. Further they pledge themselves to do all that is possible to reestablish those entomologists who enter the service in their chosen field of entomology when they shall again find themselves free to resume their civilian occupation.—2-7-42.

E. N. CORY	A. S. HOYT
S. A. GRAHAM	L. M. PEAIRS
J. S. HOUSER	E. F. PHILLIPS, *Chairman*

The Insecticide Supply Situation

Final Report of Special Committee

The Committee issued three reports in 1942, dated March 16th, April 20th, and October 28th. These reports, in mimeographed form, were sent by Dr. Ernest N. Cory, Secretary of the Association, to 101 Entomologists who, because of their official positions, were responsible for recommendations on insect control. The request was made that the reports should be circulated among the entomological associates of those individuals who received them. The first two reports were published in the April issue of the JOURNAL under "Scientific Notes" and the third report will be similarly published.

On March 21, 1942, the Bureau of Entomology and Plant Quarantine, U.S.D.A., issued the first of a series of War Letters for Entomology and Plant Quarantine. These War Letters, issued at frequent intervals throughout the year, carried current information on the availability of supplies which might have a bearing on farming operations for production of food. Preference Orders, Executive Orders, Directives, and memoranda of various Government agencies were painstakingly reviewed and condensed abstracts of the essential information were included in these War Letters. The Bureau performed a service of inestimable value to Entomologists in 1942 by establishing this timely publication and it is hoped that the War Letter may be continued in 1943.

The War Letter was sent to a restricted mailing list which was made up of essentially the same individuals as those who received the releases from this Committee. This restricted mailing list was and still is, because of economy, limited in number and cannot be extended. The Committee could not have performed the service rendered by the War Letter since its members could not have spent the time to review the various documents and abstract them; nor would it have been wise to spend Association funds to duplicate this service. Consequently, the releases from this Committee were confined to the presentation of the over-all picture on insecticide supplies at the beginning of the 1942 season, the limitation order on rotenone, and the need for conservation. The release in October gave a forecast of the supply situation for 1943 as it appeared at that time.

The Agricultural Insecticide and Fungicide Association issued No. 1, Vol. 1, of its *A.I.F. News* in December, 1942. The first issue contained an article on the Supply Outlook on Insecticides and Fungicides for 1943. Current information on the same subject will be presented from time to time. Any Entomologist or Plant Pathologist will be placed on the mailing list to receive the *News* if he so wishes.

In view of the fact that Entomologists now have available either one or both of the two publications which have been discussed, and since these will perform the service which it was contemplated would be needed by Entomologists when this Committee was formed, it would seem that there would be no further functions to be performed by the Committee. This thought, together with a proposal for the termination of this special Committee, was submitted to President Weiss. The suggestion, discussed by members of the Executive Committee, met with their approval. This release constitutes the final report of the Committee.

It is interesting to note the insecticide picture at the opening of the season in 1943 and that which existed in early 1942. The available supply of rotenone-bearing materials for 1943 may be approximately half of the 1942 supply with end-use specified and the rotenone percentage of dusts restricted to 0.5 per cent. The quantity of pyrethrum available for agricultural use will be limited. Arsenicals probably will be adequate for cotton growers, fruit growers, and those who produce food or other economic crops in 1943 but cryolite or nicotine sulphate, which are more plentiful, should be substituted where possible. Nicotine production will be increased and cryolite supplies should be 25 to 30 per cent above 1942. With this over-all picture in mind, this Committee has reviewed certain information and experimental data. Certain suggestions which may be useful to Entomologists are presented in this report.

The fact that cryolite and fluosilicates will be more plentiful in 1943 than they were in 1942 indicates the desirability of promoting their use, wherever feasible, in place of arsenicals and rotenone-bearing materials. It is recognized that in some cases it will be necessary to emphasize with the growers seasonal restrictions or special precautions connected with their use. Many bulletins have been published in past years containing specific recommendations on fluorides for control of such insects as cabbage worms, flea beetles, Mexican bean beetles, apple flea weevil in pre-bloom sprays, and codling moth in second brood sprays in the Pacific Northwest. Recent recommendations covering the use of cryolite as an alternate insecticide which have come to the attention of this Committee indicate the type of timely information which might be issued in different States wherever applicable. These include Letter No. 2, "Insect Control on Beans," Howard, leader of one of the groups of the Committee on Coordination of Entomology with the War Effort, A.A.E.E., and the recent spray schedule for 1943 issued by New York State. Undoubtedly other revised spray schedules emphasizing the ways in which cryolite may be used have already been issued which have not been called to the attention of this Committee. Attention should always be called to the fact that lime or any materials containing calcium should not be used with the fluorides. The Bureau of Entomology and Plant Quarantine has reviewed and is continuing to review its publications and recommendations on the use of insecticides in light of the scarcity of certain materials. The Committee has been assured that the Bureau will gladly supply any information available to them on alternate or substitute materials that may be used to control various pests. As a part of this effort they are preparing for early publication a manuscript which, together with the information published in Circular E-466, will bring together the information on cryolite as an insecticide up to December 31, 1941.

Since the supply of rotenone-bearing materials will be limited in 1943 as far as agricultural needs are concerned, the Committee has contacted many Entomologists and obtained their reports on various experiments designed to stretch the supply of these materials. One approach to this problem has been the use of mixtures of rotenone charges with thiocyanates, with nicotine, or with all three toxicants. One of the principal uses of rotenone-bearing materials has been for control of the pea aphis on peas. Wilson and Lilly, working independently on this insect in Wisconsin, and Walker in Virginia, obtained data which indicated that dust mixtures containing 0.4 per cent to 0.2 per cent rotenone plus 2 to 3 per cent of a thiocyanate (*Lethane 60*, *Loro*, or

Thanite) were as toxic as dust mixtures containing 0.75 to 1 per cent rotenone. On the other hand, negative or inferior results were reported with similar combinations as compared with straight rotenone by Pepper, Glasgow, and Hutson. Thomas of Texas, working with the rotenone-thiocyanate combination, reported control of turnip aphid, cabbage worms, melon worms, and Colorado potato beetle. Pepper (laboratory and field tests in New Jersey), working with dusts containing 0.5 per cent rotenone alone and with added thiocyanates (1 to 5 per cent) and with pyrethrum dusts with and without thiocyanates (1 to 5 per cent), obtained either reduced toxicity or no higher toxicity with the dusts containing the thiocyanates. Test insects included Mexican bean beetle, Colorado potato beetle, striped cucumber beetle, European corn borer, potato aphis, cabbage looper, and six-spotted leafhopper on lettuce. He reported injury to corn, tomato, cantaloupe, string beans, and lima beans from rotenone-thiocyanate dusts both in his own tests and by growers with commercial mixtures. Several workers reported that no increase in toxicity was secured by the addition of thiocyanates to a rotenone-bearing dust for control of Mexican bean beetle, cabbage worms, cucumber beetle, and diamond-back moth.

Lilly, Walker, and Pepper, working with pea aphid, have all reported that the rotenone content in a dust may be reduced from 1 per cent or 0.75 per cent to half these strengths by the addition of approximately 2.0 per cent free nicotine or the equivalent in nicotine content in the form of *Black Leaf 10*. The addition of 2 to 10 per cent sulfur increases the effectiveness of this combination. Lilly advocates the addition of certain materials of a hygroscopic nature to this dust. *Black Leaf 10*, free nicotine absorbed on fine tobacco dust, has been used as a source of nicotine in making up dusts of 3 to 4 per cent strength for control of various vegetables aphids by different workers. *Black Leaf 10* would seem to have certain advantages as a source of nicotine in place of *Black Leaf 40* in making nicotine dusts. Negative results are reported with dusts containing *Black Leaf 10* without rotenone for control of diamond-back moth and Southern green plant bug. *Black Leaf 155*, a fixed nicotine composition, which has been largely used for control of codling moth on apples, has been used in dusts for control of European corn borer. Carruth, from New York, and Pepper, in New Jersey, have obtained good control of the European corn borer on sweet corn with *Black Leaf 155* diluted with walnut shell flour so that the mixture contained 4 per cent actual nicotine. This material was applied as a dust. Pepper has also obtained equally good results with a mixture of *Black Leaf 155* diluted so as to contain 4 per cent nicotine using *Loomkil* fibrous talc, 25 per cent dusting sulfur, and 0.2 per cent wetting agent, either *Ultrawet* or *Vatsol OS*. Nicotine dusts have not proven so satisfactory in the Central States and Flint reports that considerably higher percentages of nicotine from *Black Leaf 155* were necessary to obtain satisfactory control of the European corn borer in heavier infestations. Nicotine dusts made with *Black Leaf 155* and lime have been tested successfully for control of plant lice and cabbage worms.

The Committee believes that information which has already been developed by certain workers in connection with the role which diluents play in contact dusts indicates the need for more investigation along this line. It would seem to be apparent that it is no longer satisfactory for an investigator to simply indicate that talc or clay has been used as an extender. This material should be identified by indicating the exact geographical origin of the material. Further information would seem to be desirable on the value of non-toxic supplements in rotenone dusts. The comparative effectiveness of freshly mixed dusts and those aged in storage should be carefully studied since there is some evidence of loss of toxicity in stored dusts in the case of both rotenone-thiocyanate and rotenone-nicotine mixtures.

Favorable experimental results have been reported with a basic copper arsenate of small particle size and low water soluble arsenic for the control of such insects as leaf worm and boll worm on cotton, soya caterpillars, and husk fly and codling moth on walnuts. It has also been tested as an all-purpose spray on tomatoes and beans. The same compound having some water solubility, manufactured by a different company, seems to have given good results for control of certain diseases on potatoes and tomatoes. Probably experimental quantities of either of these products will be available to investigators and the two manufacturers which were named in the second report of the Committee should be contacted for samples.

Certain organic insecticides, namely, phenothiazine, phenothioxin, phthalonitrile, 2-chlorofluorene, and xanthone, have been tested to some extent either on a Laboratory basis or more extensively in the field. The Committee feels that these are worth further investigation on different insects of economic importance in order that final conclusions may be reached as to their ultimate field of usefulness. Any member of the Committee will be glad to furnish the names of companies from which samples of these compounds may be obtained.

The Committee expresses its appreciation to the Entomologists who furnished unpublished experimental data secured in 1942 and for their permission to refer to these data in this report.

The Committee expresses its appreciation to the Entomologists who furnished unpublished experimental data secured in 1942 and for their permission to refer to these data in this report.

The Committee wishes to thank the officials in various Government agencies and Mr. L. S. Hitchner, Secretary of the Agricultural Insecticide and Fungicide Association, for their hearty cooperation during the past year.—January 26, 1943.

R. C. ROARK
C. C. HAMILTON
J. L. HORSFALL, *Chairman*

HORTICULTURAL INSPECTION NOTES

Federal Quarantines and Administrative Instructions

The Japanese beetle quarantine regulations were amended effective January 14, 1943, for the sole purpose of extending the regulated areas in Maryland, New York, Pennsylvania, Virginia, and West Virginia. The entire state of Maryland is now within the regulated area except the southernmost section of the Western Shore and two small areas in the westernmost counties of the state. Additions in New York, Pennsylvania, and Virginia, are limited to the cities or towns of Silver Creek, Fulton, and Oswego, N. Y., the borough of Wesleyville, in Erie County, Pa., and Pulaski, Radford, Roanoke, West Point, and Woodstock, Va. The new area in West Virginia includes the counties of Barbour, Lewis, and Upshur, the city of Hinton, minor additions in Kanawha County, and Rowlesburg, in Preston County.

That part of the regulated area from which the movement of fruits and vegetables by motortruck or refrigerator car is under regulation—the more heavily infested area—has been extended to include a district each in Norfolk and Princess Anne Counties, Va., sections of the Eastern Shore of Maryland previously excluded from this area, nine townships in Cumberland and York Counties, Pa., and a few townships each in four New Jersey counties. No other changes were made in the regulations.

White-fringed beetle administrative instructions relating to partial vacuum fumigation with methyl bromide were revised January 18, 1943, to provide for a series of dosage schedules modified to compensate for variations in the soil-ball temperatures and permit fumigation in most instances without the necessity of heating the soil balls.

The white-fringed beetle quarantine was revised effective December 28, 1942, to extend the regulated areas to include parts of the North Carolina counties of New Hanover, Pender, and Wayne, owing to the discovery during the past season of infestations of beetles at Wilmington and other points in the State. New areas were also added in Alabama and Mississippi and some changes were made in the list of restricted articles and conditions of certification. Certain articles were exempted from certification requirements of the above quarantine until June 15, 1943, under a revision of Circular B.E.P.Q. 485, which became effective December 28, 1942.

New schedules for methyl fumigation of potted or bare-rooted plants and for methyl bromide solution for treating soil for the Japanese beetle, were authorized in two supplements to circular B.E.P.Q. 499, both effective September 18, 1942.

The list of species permitted shipment under the black stem rust quarantine was modified in a revision of Circular B.E.P.Q. 385, dated December 15, 1942.

Administrative instructions relating to the pink bollworm quarantine issued effective October 1, 1942, removed the fumigation or roller treatment requirements for linters produced from sterilized seed originating in the heavily infested area (Circular B.E.P.Q. 493, second revision).

State Quarantine and Regulations

The European corn borer quarantines of Iowa, Kansas, Missouri, and Nebraska were revised on November or December 1942 to include additional infested areas comprised of 20 counties in Iowa and 17 in Missouri. The quarantines are uniform as to areas and products regulated, the latter being limited to corn and broomcorn, sorghum and Sudan grass (except seed), and the entire plants of gladiolus and dahlia, except the corms or tubers. Conditions of entry differ, however, in that Nebraska accepts the certificate of inspection for floral plants only, and prohibits the entry of products such as corn and broomcorn unless processed or manufactured; Iowa and Missouri accept the inspection certificate for floral plants or the fumigation of any of the host plants; while Kansas accepts either the inspection or the fumigation of any of the host plants.

Owing to the discovery of the Oriental fruit moth in California an intrastate quarantine was placed, October 28, 1942, on the shipment of host plants and fruits from the entire counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura and part of Santa Barbara County. The State of Washington extended its quarantine (No. 11) pertaining to the above pest to apply to all the above counties except Ventura County, and also to the State of Oklahoma, and provided for a methyl bromide schedule for fumigation of bare-rooted trees.

The California citrus white-fly quarantine as revised effective August 8, and amended effective September 22, 1942, places all of the United States except Arizona under quarantine, designates 11 States as infested, and requires defoliation or treatment or special permit for entry of the host plants from the infested area and a certificate as to origin in the case of host plants shipped from noninfected area. The host list has been revised to eliminate several species of plants and to add camellia and nine genera and hybrids closely related to citrus.

The Arizona quarantine relating to the satin moth was revoked effective December 14, 1942.

The interstate Nursery Regulations of The South Carolina Crop Pest Commission were revised effective December 1, 1942, providing for reciprocal agreements with other States as to requirements pertaining to the permit tags, dual invoices, and fees. The regulations apply to all plants and parts of plants shipped into the State for propagating purposes.

State Quarantines Revoked

In accordance with recommendations of the Western Plant Board at its annual meeting in 1942, the States of Arizona, California, and Washington recently revoked their satin moth quarantines, and Oregon and Washington revoked their orders pertaining to the tomato pinworm. The Wisconsin quarantine relating to European corn borer was repealed effective February 15, 1943.

European Corn Borer Quarantines Extended

The States which have thus far extended their European corn borer quarantines owing to recent infestations in Iowa and Missouri, include Arizona, California, Iowa, Kansas, Missouri, Nebraska, and Oregon. Only the Arizona order applies to all parts of the newly infested States, the quarantines of the other States uniformly limiting the restrictions to infested counties in Iowa and Missouri, in consideration of the intrastate and interstate quarantines recently enacted by these two States.

Oriental Fruit Moth Quarantines

The Oriental fruit moth quarantines of Arizona, California, Oregon, Utah, and Washington have been recently revised to add Oklahoma and the recently infested counties in California to the infested areas. The orders of Oregon, Utah, and Washington apply to the California counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and part of Santa Barbara, while the quarantines of Arizona and California extend also to Ventura County. The quarantines are uniform as to the list of restricted articles and fairly so as to the conditions of certification.

Grape Phylloxera Quarantine Treatment

An oil-nicotine dip for grape Phylloxera is authorized as an alternate for hot-water treatment in the Washington State quarantine as revised January 19, 1943.

Peach Quarantines

Georgia's standard quarantine on the phony peach disease as revised effective February 15, 1943, recognizes an appreciable reduction in area infected by the disease in the past 3 years. The quarantine is lifted as to the entire States of Kentucky and North Carolina and as to a considerable number of counties in Arkansas, Mississippi, South Carolina, Tennessee, and Texas. The regulated area is now comprised of parts of these 5 States, 2 counties in Illinois, 4 in Missouri, and the entire States of Alabama, Florida, Georgia, and Louisiana.

Owing to a material reduction in the area infected by the peach mosaic disease in California, Quarantine Regulation No. 1 of that State was revised December 18, 1942, to lift the restrictions on Orange and Imperial Counties and the eastern portion of Riverside County.

The State of Washington on January 19, 1943, revoked its quarantine on the peach mosaic disease and on the same date revised Order No. 9 pertaining to peach yellows and peach rosette to embargo shipments of the host plants from presently known infected States, to require that such shipments from noninfected States be labeled to show where the trees were grown or the buds or stock obtained, and further to specify that anyone shipping any nursery stock into the State shall send notice of shipments to the director of agriculture and the local inspector, and mark the shipments to show the contents.

Mexican Fruitfly Quarantine

The U. S. Department of Agriculture and the Texas State Department of Agriculture announce the modification of the Mexican fruitfly quarantine regulations by extending the harvesting season for oranges and grapefruit in the Texas counties of Brooks, Cameron, Hidalgo, and Willacy to the close of May 31, for this year, on condition that sterilization by approved methods will be required for oranges and grapefruit if the conditions of infestation involve a risk of spread of the fruitfly. The harvest season normally closes under the regulations on April 30, except that the grapefruit harvest in the counties of Dimmit, La Salle, and Webb ends on the last day of February, and no modification is made in the harvesting season in those counties. The harvest season begins on September 1 of each year.

Pesticides Requirements Committee for Canada Formed Under Chairmanship of Dominion Entomologist

The Combined Food Board of the United Nations is charged with the responsibility of allocating available pesticides and other essential materials according to the needs of the nations. The *Agricultural Supplies Board*, in conjunction with the *Canadian Wartime Prices and Trade Board*, who co-operate with the *Food Board*, decided upon the formation of a technical advisory committee to assist in the preparation of estimates of Canadian pesticide requirements. This committee, known as the Pesticides Requirements Committee, has been set up in Ottawa under the Chairmanship of Mr. L. S. McLaine, Dominion Entomologist. The purpose of the Committee is twofold, namely, to estimate Canadian pesticide needs, and to gather information on substitute materials for those found to be in short supply.

This information is being obtained through the co-operation of the technical men in the Federal and Provincial Services in the various provinces. In this work due consideration is being given to the revised agricultural production schedule to meet Canadian war commitments. The personnel of the Committee is made up of representatives of the Science Service, Dominion Department of Agriculture, as follows:

Division of Entomology

L. S. McLaine, *Chairman*
G. F. Manson, *Secretary*
H. G. Crawford
C. R. Twinn

Division of Bacteriology

A. G. Lockhead

Division of Animal Pathology

C. A. Mitchell

Division of Botany

G. A. Scott

Wartime Prices and Trade Board

G. S. Peart (*ex officio*), *Pesticides Administrator*
A. M. W. Carter (*ex officio*), *Director of Pesticides*

Ottawa, Ontario
February 18, 1943

SERVICE NOTES

★ Donald Cameron ★

Donald Cameron, Ithaca, N. Y., has been reported lost in action over Malta. He was a Navigator with the Royal Canadian Air Force.

First Lieutenant Basil G. Markos

Dr. Basil G. Markos who received his Ph.D. in Entomology at Ohio State University and was employed by the Crop Protection Institute at Durham, North Carolina has accepted a commission as a First Lieutenant in the Sanitary Corps and reported to Camp Pickett, Virginia for temporary duty. Lt. Markos is being sent to Camp Shelby, Mississippi for entomological work with the Army Medical Department.

First Lieutenant Oscar V. Lopp

Oscar V. Lopp of the Indiana Conservation Department has recently been commissioned in the Sanitary Corps for entomological work with the Army. Lt. Lopp reported to the Pool at Camp Grant, Illinois and is being assigned to Ft. Belvoir, Virginia for duty with the Military District of Washington.

First Lieutenant Edwin R. Helwig

Dr. Edwin R. Helwig who has been teaching at the University of Pennsylvania has accepted a commission as First Lieutenant in the Sanitary Corps and is now on temporary duty at Camp Pickett, Virginia awaiting assignment to a permanent station.

Major Samuel G. Dews

Samuel G. Dews, Entomologist in the Sanitary Corps has been transferred to Headquarters Fourth Service Command, Atlanta, Georgia and has recently been promoted to the grade of Major. Major Dews was formerly employed by the U. S. Burea of Entomology and Plant Quarantine.

Captain Walter W. Fassig

Walter W. Fassig, Entomologist on duty with the Sanitary Corps at Camp Livingston, Louisiana, has recently been promoted to the grade of Captain.

Captain Irwin H. Gilbert

Irwin H. Gilbert, Entomologist in the Sixth Service Command Laboratory at Fort Sheridan, Illinois was promoted to the grade of Captain recently. Captain Gilbert was formerly of Ohio State University.

Captain William B. Owen

Dr. William B. Owen formerly of the University of Minnesota is now a Captain in the Sanitary Corps and is on duty at Carlisle Barracks, Pennsylvania.

Captain K. C. Emerson

K. C. Emerson, A. & M. College, Stillwater, Okla., Capt., U. S. A., has been reported missing from the Philippines and is believed to be a prisoner of the Japanese.

R. W. Brubaker

R. W. Brubaker of the Bureau of Entomology and Plant Quarantine is now in active service in the United States Navy. Mr. Brubaker has been serving as a gunner on merchant ships and was recently aboard a ship which was torpedoed. Mr. Brubaker and others of the crew spent 13 days in an open boat before being picked up. All members of the group survived.

Captain F. W. Fisk

F. W. Fisk, formerly of 1510 21st St., N.W., Washington, D. C. Present address: Capt., U. S. A., Medical Section, SOS, Army Post Office 886, New York City. In November 1941, Captain Fisk was in Burma as a member of the Medical Commission of the U. S. Public Health Service to China, working on the protection of workmen on the Yunnan-Burma Railway from malaria. He escaped from the Japanese during the invasion and went to New Delhi, India, and was commissioned Captain, Medical Section, U. S. A. (anti-Malaria Officer).

Lieutenant W. D. Reed

W. D. Reed, BEPQ, Richmond, Va., enlisted in the Army last July, and was commissioned Lieutenant in December 1942. He is stationed at Edgewood Arsenal, Post Headquarters. In addition to his other duties, he is acting as Sanitation Officer for the post.

Lieutenant Donald MacCreary

Donald MacCreary, Lt. (s.g.) USNR, recently completed special work at the Naval Medical School, Bethesda, Md., and has left for foreign duty. He was formerly with the Delaware Experiment Station.

Norman G. Platts

Norman G. Platts, of the Bureau of Entomology and Plant Quarantine, is serving as Engineering Sanitarian, Malaria Control in War Areas, with the U. S. Public Health Service at Atlanta, Georgia.

Lieutenant Colonel W. B. Herms

Dr. W. B. Herms, of the University of California, has been called to active service in the Sanitary Corps of the U. S. Army with the rank of Lieutenant Colonel and reported for duty at Carlisle Barracks, Pennsylvania, late in January.

Captain W. W. Middlekauff

Woodrow W. Middlekauff, formerly of Cornell University, was promoted to the rank of Captain in December, 1942. Captain Middlekauff is now on duty with the Sanitary Corps in the Fourth Service Command Laboratory, Fort McPherson, Georgia, where he is engaged in Medical Entomology and the training of personnel for entomological work in the different Army Posts in the southeastern states.

LT. COLONEL FREEBORN

Dr. Stanley B. Freeborn, of the University of California, has been commissioned a Lieutenant Colonel in the Army. He may be addressed as "Senior Surgeon, Malaria Control in War Areas, 505 Volunteer Bldg., Atlanta, Georgia."

LT. COLONEL ANDREWS

Word has just been received that Major Justin M. Andrews has been promoted to the rank of Lieutenant Colonel and that John T. Bigham has been promoted from First Lieutenant to Captain. Both Colonel Andrews and Captain Bigham are engaged in entomological work overseas.

LT. COLONEL KING

Dr. W. V. King, recently a Major in the Army, has been promoted to Lieutenant-Colonel, He is head of the Entomological work in the 4th Service Command, Fort McPherson, Georgia. (Now Overseas.)

MAJOR STANLEY J. CARPENTER

To Major Carpenter, who is on duty with the Sanitary Corps in the laboratory of the Fourth Service Command, Ft. McPherson, Georgia, the JOURNAL is indebted for much of the information concerning entomologists in the Army. Major Carpenter contributed many of the Service Notes appearing in this issue of the JOURNAL.

MAJOR L. A. STEARNS

March 1, 1943. "Serving as Malariologist with the Persian Gulf Command, covering an area the size of from Wilmington, Delaware, to Columbus, Ohio. The changes in weather are from a winter temperature such as we have in Delaware, to terrible summer heat of 168° F. At that temperature native boys constantly wet down bed sheets with as cool water as possible before one turns in. He (Major Stearns) flies from place to place in this territory and will lay out all the work on this anti-malarial campaign." (From a letter from Mrs. Stearns to Dr. Cory)

MAJOR MARSHALL HERTIG

Dr. Marshall Hertig, who has been associated with the Harvard Medical School and the Peruvian Government, Lima, Peru, has accepted a commission as a Major in the Sanitary Corps of the United States Army. Major Hertig is now in the Medical Replacement Center, Washington, D. C.

CAPTAIN BERTRAM I. GERRY

Dr. Bertram I. Gerry, who has been employed as Entomologist by the Massachusetts State Department of Agriculture for several years, has been commissioned as a Captain and recently reported to the Medical Replacement Pool at Camp Joseph T. Robinson, Arkansas for duty with the Sanitary Corps.

CAPTAIN ALEXANDER B. KLOTS

Dr. Alexander B. Klots who has been instructor in Biology at the City College of New York has accepted a commission as Captain in the Sanitary Corps of the United States Army and has reported to the Medical Replacement Pool at Camp Joseph T. Robinson, Arkansas.

FIRST LIEUTENANT CLARENCE H. HILL

Mr. Clarence H. Hill, entomologist with the North Carolina Department of Agriculture, is now a First Lieutenant in the Sanitary Corps. Lieutenant Hill has recently reported to the Medical Replacement Pool at Camp Pickett, Virginia.

FIRST LIEUTENANT WAYNE L. HOWE

Mr. Wayne L. Howe, who has been associated with the Department of Commerce, Washington, D. C., is now a First Lieutenant in the Sanitary Corps and has reported to the Medical Replacement Pool, Army Medical Center, Washington, D. C., where he is awaiting further assignment.

FIRST LIEUTENANT JUSTIN W. LEONARD

Dr. Justin W. Leonard, who has been associated with the Michigan Department of Conservation, as aquatic biologist, has recently accepted a commission in the Sanitary Corps of the United States Army and is now in the Medical Replacement Pool at Camp Grant, Illinois.

FIRST LIEUTENANT THEODORE MCGREGOR

Mr. Theodore McGregor, who has been employed as entomologist with the Texas State Health Department for several years has accepted a commission in the Sanitary Corps of the United States Army.

FIRST LIEUTENANT WILLIAM J. SPICER

Mr. William J. Spicer, who has been with the United States Bureau of Entomology and Plant Quarantine in Texas, has accepted a commission as First Lieutenant in the Sanitary Corps of the United States Army and is now in the Medical Replacement Pool at Camp Barkeley, Texas.

FIRST LIEUTENANT CALVIN L. RITCHIE

Mr. Calvin L. Ritchie, who has been employed by the United States Department of Agriculture, Portland, Oregon, has recently been commissioned as First Lieutenant in the Sanitary Corps and has reported to the Medical Replacement Pool at Camp Barkeley, Texas.

FIRST LIEUTENANT NATHANIEL TISCHLER

Dr. Nathaniel Tischler, who has his Ph.D. in entomology from Rutgers University, has accepted a commission as First Lieutenant in the Sanitary Corps and recently reported to the Medical Replacement Pool, Army Medical Center, Washington, D. C.

FIRST LIEUTENANT CLARENCE B. DOMINICK

Clarence B. Dominick, who was formerly engaged in entomological research at Virginia Polytechnic Institute has recently transferred from the Infantry Reserve to the Sanitary Corps and is now on duty at Camp Davis, N. C.

FIRST LIEUTENANT FRANKLIN S. BLANTON

Franklin S. Blanton, who has been on duty at the Eighth Service Command Headquarters, has recently been transferred to Camp Chaffee, Arkansas, for duty with the Medical Department.

FIRST LIEUTENANT ERNEST R. TINKHAM

Ernest R. Tinkham, Entomologist in Sanitary Corps has recently been assigned to Boca Raton Field, Florida, for entomological work in connection with Malaria control. Lt. Tinkham has spent several years in Entomological work in the Orient.

LIEUTENANT HERBERT E. MILLIRON

First Lieutenant Herbert E. Milliron has been transferred from Camp Grant, Illinois, to Fort Knox, Kentucky. He is assigned to entomological work.

LIEUTENANT ERSKINE M. LIVINGSTONE

Erskine M. Livingstone, of New Orleans, entered the army as a private during the summer of 1942 and was stationed at Ft. Lewis, Washington. He has recently been commissioned a First Lieutenant in the Sanitary Corps and is on temporary duty at Camp Pickett, Virginia.

F. F. BIBBY

F. F. Bibby enlisted in the United States Navy on January 27, 1943 and has been given the rating of Chief Pharmacist's Mate. Mr. Bibby is stationed at Pensacola, Florida and may be reached at the following address: C. Ph. M. F. F. Bibby, U. S. Naval Hospital, Pensacola, Florida.

LIEUTENANT OWEN H. GRAHAM

First Lieutenant Owen H. Graham, formerly of Brownwood, Texas, and in the service at El Paso, Texas, has been transferred to the Fourth Service Command at Camp Hoffman, North Carolina. He is attached to the Sanitary Corps in an entomological capacity.

LIEUTENANT JOHN B. HULL

John B. Hull, of the Bureau of Entomology and Plant Quarantine, has been commissioned a Lieutenant (j.g.) in the United States Navy and is now stationed at the Malaria Control Laboratory, Marine Barracks, Hodnot Point, New River, North Carolina.

LIEUTENANT S. E. SHIELDS

S. E. Shields, of the Bureau of Entomology and Plant Quarantine, has accepted a commission as a Lieutenant in the Sanitary Corps of the United States Army and is stationed at Key West Barracks, Key West, Florida.

NEW ENTOMOLOGY UNIVERSITY

The Entomology Section of the Fourth Service Command Laboratory has been recently moved into a new building at Fort McPherson, Georgia. The new entomology laboratory consists of an office, a laboratory room with work spaces for 8 entomologists, a store room for entomological supplies, a modern insectary with controlled temperature and humidity. The Fourth Service Command Laboratory either identifies or confirms identifications of mosquitoes collected at the different posts within the command and carries on a teaching program for entomological personnel of the different posts.

FIRST LIEUTENANT WILLIAM R. HORSFALL

Dr. William R. Horsfall, Assistant Professor in Entomology at the University of Arkansas is now a First Lieutenant in the Sanitary Corps and is on duty in the Medical Replacement Pool at Camp Grant, Illinois.

FIRST LIEUTENANT GUSTAF F. AUGUSTSON

Mr. Gustaf F. Augustson who has been employed by the Allan Hancock Foundation, Los Angeles, California has received a commission as First Lieutenant in the Sanitary Corps of the United States Army and is now on duty at Carlisle Barracks, Pennsylvania.

EDWIN W. KING

Mr. Edwin W. King, formerly of the Virginia Polytechnic Institute, Blacksburg, entered the army in September and is now stationed at Camp Edwards, Mass. Mr. Grayson is attached to the Camp Surgeon's Office as Camp Entomologist. In addition to general entomological supervision Mr. King has prepared and delivered a course of lectures on Sanitary and Medical Entomology to groups of Sanitary Technicians assigned, from time to time, to the Hospital for training. Mr. King is at present rated as Corporal Technician and may be addressed as follows: Corporal Edwin W. King, Barracks 3869, Station Hospital, Camp Edwards, Mass. Mr. King is a member of the Association and is co-author of a paper which will appear in an early number of the JOURNAL.

OVERSEAS ASSIGNMENTS

The following entomologists have recently received overseas assignments for Malaria Survey Work: Captain Frederick W. Whittemore, Jr., First Lieutenant Samuel C. Billings, First Lieutenant Richard F. Peters, First Lieutenant Roger L. Pierpont, First Lieutenant Bryant E. Rees.

ENTOMOLOGICAL SCHOOL

Captain F. S. Arant, Camp McCain, Mississippi; First Lieutenant J. G. Franclemont, Camp Rucker, Alabama; First Lieutenant B. D. Burks, Camp Van Dorn, Mississippi; and First Lieutenant M. A. Manzelli, Camp Gordon Johnston, Florida who are Entomologists in the Sanitary Corps attended a course in mosquito identification at the Fourth Service Command Laboratory from January 18–31, 1943.

FIRST LIEUTENANT HARRY E. BROWN

Mr. Harry E. Brown, instructor in entomology at the University of Missouri, is now a First Lieutenant in the United States Army and has recently reported to the Medical Replacement Pool at Camp Barkeley, Texas where he is awaiting a permanent assignment for duty in the Sanitary Corps.

FIRST LIEUTENANT EDWARD T. BOARDMAN

Dr. Edward T. Boardman, who has been associated with the Johns Hopkins Cranbrook Institute of Science in Michigan, as aquatic biologist, has recently been commissioned as a First Lieutenant in the Army and is now in the Medical Replacement Pool at Army Medical Center, Washington, D. C.

UNIVERSITY OF ILLINOIS ENTOMOLOGICAL GRADUATES IN THE ARMED FORCES

CORPORAL CURTIS BENTON

Corporal Curtis Benton (M.S. in Entomology, University of Illinois, 1924) was stationed in Company C, 4th Platoon, Billings Medical Technical School, Fort Benjamin Harrison, Indianapolis, Indiana, and has now been returned to Purdue University.

FIRST LIEUTENANT BARNARD D. BURKS

Lieutenant Barnard D. Burks (Ph.D. in Entomology, University of Illinois, 1937) has been engaged in entomological work in the Sanitary Corps of the U. S. Army since June 1942. He was stationed at Camp Van Dorn, Mississippi, until early in February when he was reported to be leaving for overseas duty. His address is 12th Malarial Survey Unit, A.P.O. 3658, c/o Postmaster, New York City.

CORPORAL EDWARD BUSHING

Corporal Edward W. Bushing (B.A. in Entomology, University of Illinois, 1942) entered the U. S. Army on October 7, 1942. He is a sanitary inspector in Det. Med. Dept., Hammer Field, Fresno, California.

LIEUTENANT DON DECOURSEY

Lieutenant Don DeCoursey (Ph.D. in Entomology, University of Illinois, 1941) received his commission in the Medical Corps of the U. S. Navy in April, 1942, when he reported for duty at the Norfolk Navy Yards, Virginia. On November 23 he was sent to the National Naval Medical Center at Bethesda, Maryland, for special training in malariology and early in February he left for overseas duty. His address is Malariology Department, Naval Air Station Trinidad, British West Indies.

CAPTAIN FRANK W. FISK

Captain Frank W. Fisk (B.S. in Entomology, University of Illinois, 1936) is a member of the American Medical Commission, sponsored by the U. S. Public Health Service, and is stationed somewhere in India. He is engaged in mosquito control work. His address is Medical Section, S.O.S., A.P.O. 629, New York, N.Y.

J. E. FRALEY

John E. Fraley (M.S. in Entomology, University of Illinois, 1941) is working for the Red Cross somewhere in England, where he is in charge of recreation in army camps. Previous to entering into this service he was teaching biology at Normal University, Normal, Illinois.

ENSIGN ROBERT GOLDBERG

Ensign Robert Goldberg (B.S. in Entomology, University of Illinois, 1937) is located at the U. S. Naval Training Station, Patton Hall, Princeton University, Princeton, N. J.

RALPH HAAG

Ralph Haag (B.A. in Entomology, University of Illinois, 1942) is enlisted in the U. S. Naval Reserves. His present address is U.S.N.R. Midshipman's School (Room 1308 John Jay Hall), Columbia University, New York City.

PRIVATE HARRY HOOGSTRAAL

Private Harry Hoogstraal (M.S. in Entomology, University of Illinois, 1942) was inducted into the Army on May 21, 1942. After serving at Camp J. T. Robinson, Arkansas, and at Fort Benning, Georgia, he was transferred, on February 10, to the Fourth Service Command Laboratory at Atlanta, Georgia.

LIEITENANT (J.G.) KENNETH L. KNIGHT

Lieutenant (j.g.) Kenneth L. Knight (Ph.D. in Entomology, University of Illinois, 1941) has been engaged in mosquito control work in the Medical Corps of the U. S. Navy since August, 1941, when he received a commission as Ensign. He was raised to the rank of Lieutenant in October, 1942. Since July, 1942, he has been stationed "somewhere in the South Pacific." His address is Navy 600, c/o Fleet Post Office, San Francisco, California.

PFC. GEORGE LUDVIK

Pfc. George Ludvik (B.A. in Entomology, University of Illinois, 1941) reported for duty in the U. S. Army on October 26 at Scott Field, Illinois. He was soon sent to Camp Van Dorn, Mississippi, where he is at present working in the Det. Med. Department at the Station Hospital.

PRIVATE MARSHALL MAGNER

Private Marshall Magner (B.A. in Entomology, University of Illinois, 1939) has been in the armed forces since October 14, 1942. His latest known address was 14th Malaria Survey Unit, N.O.S.A. #4, T18-14, New Orleans, La.

FIRST LIEUTENANT RALPH B. MARCH

First Lieutenant Ralph B. March (B.A. in Entomology, University of Illinois, 1941) entered the U. S. Army in June, 1942 at Edgewood Arsenal, Maryland. After several weeks' training there, he reported for duty as Assistant Chemical Officer of the IV Ground Air Support Command. Army Air Base, Thermal, California.

LIEUTENANT W. E. MCCAULEY

Lieutenant W. E. McCauley (M.S. in Entomology, University of Illinois, 1936) has been on active duty in the U. S. Army since July 1942. During the second week in February he sailed from the west coast for overseas service.

FIRST LIEUTENANT CARL O. MOHR

First Lieutenant Carl O. Mohr (Ph.D. in Entomology, University of Illinois, 1934) received his commission in the Sanitary Corps of the U. S. Army in August, 1942, and is at present located at Camp Breckenridge, Kentucky, in the Medical Section (1570 Service Unit).

CORPORAL ANDREW R. PARK

Corporal Andrew R. Park (A.B. in Entomology, University of Illinois, 1930) is located at the 56th Evacuation Hospital, Fort Sam Houston, Texas.

ENSIGN W. LEROY PARKER

Ensign W. LeRoy Parker (Graduate Student in Entomology, University of Illinois, 1941–42) enlisted in V-7 of the U. S. Navy on July 2, 1942, and received his basic training at the Midshipmen's School, Columbia University, New York City. He was given a commission as Ensign upon graduation in October, and is now stationed at the Amphibian Training Base, Little Creek, Virginia.

PRIVATE MANUEL M. PETRAKIS

Private Manuel M. Petrakis (B.A. in Entomology, University of Illinois, 1939) has been assigned to pest control work at Chanute Field, Illinois, since early in January. His address is Det. Med. Dept., Extension Hospital, Chanute Field, Rantoul, Illinois. Before going into the service, he was employed by the Illini Pest Control & Service Co. of Urbana, Ill.

FIRST LIEUTENANT GARLAND T. RIEGEL

First Lieutenant Garland T. Riegel (M.S. in Entomology, University of Illinois, 1940) accepted a commission in the Sanitary Corps of the U. S. Army on July 22, 1942. After serving for a time at Fort Benjamin Harrison, Indiana, and at Fort Leonard Wood, Missouri, he departed for the east coast on February 7, whence he expected to sail for overseas duty. He has been engaged in insect control work. His address is 12th Malarial Survey Unit, A.P.O. 3658, c/o Postmaster, New York City.

SERGEANT CLIFFORD ROAN

Sergeant Clifford Roan, who was majoring in entomology while enrolled at the University of Illinois, left school during his Junior year and enlisted in the U. S. Army. He is at present an instructor in Meteorology Weather Observation, Base Weather Station, Chanute Field, Illinois.

FIRST LIEUTENANT ROBERT TRAUB

Lieutenant Robert Traub, who served as a graduate assistant in the Department of Entomology, University of Illinois, from 1939 to 1942, has been assigned to the Sanitary Corps of the U. S. Army since June, 1942. At present he is commanding officer of the 9th Malaria Survey Unit, N.O.S.A., New Orleans, La.

ENSIGN JAMES SLATER

James Slater (B.A. in Entomology, University of Illinois, 1942) is in V-7 of the U. S. Navy and received preliminary training aboard the U.S.S. *Prairie State*. He was called to duty on October 30, 1942. His address is U.S. N.T.S. (Recognition) 1045 Baker Hall, Ohio State University, Columbus, Ohio.

FIRST LIEUTENANT PHILIP C. STONE

First Lieutenant Philip C. Stone (Ph.D. in Entomology, University of Illinois, 1942) reported January 18, 1943, to Carlisle Barracks, Pennsylvania, as Entomologist in the Sanitary Corps of the U. S. Army. After three weeks' training he was sent to Norfolk Army Base, Virginia, H.R.P.E., as Sanitation Officer for the Army Base. Previous to entering the service he was teaching entomology at the University of Missouri.

SERGEANT BERNARD B. SUGERMAN

Sergeant Bernard B. Sugerman (B.A. in Entomology, University of Illinois, 1940) is in charge of insect control, Med. Det. A.A.F.T.S., Lincoln Air Base, Lincoln, Nebraska.

ENSIGN ROGER W. WILLIAMS

Ensign Roger W. Williams (M.S. in Entomology, University of Illinois, 1941) received a commission as Malariologist in the U. S. Navy early in February, 1943. He worked on a research fellowship in the School of Public Health, University of North Carolina, Chapel Hill, N. C., until March 1, 1943. His address is Malaria Lab. Marine Barracks, Camp Lejeune, New River, N. C.

ENSIGN CARL K. DORSEY

Ensign Carl K. Dorsey (M.A. in Entomology, University of Illinois, 1936) is now stationed at U.S.N.R., Camp Peary, Williamsburg, Va.

LIEUTENANT HERBERT F. SCHOOF

Lieutenant Herbert F. Schoof (Ph.D. in Entomology, University of Illinois, 1940) received a commission in the Public Health Service Reserve Corps on February 1, 1943 and reported for active duty at Raleigh, N.C., where he will be engaged in mosquito control work.

CHANGE OF STATIONS FOR ENTOMOLOGISTS

Lieutenant Colonel W. V. King, formerly of the United States Bureau of Entomology and Plant Quarantine and until recently was entomologist in charge of the entomological work in the Fourth Service Command Laboratory, Fort McPherson, Georgia, has recently been assigned to overseas duty at an unnamed post.

First Lieutenant Howard R. Roberts and First Lieutenant Edward S. Ross of the Eighth Service Command Laboratory, Fort Sam Houston, Texas have been resently assigned to the Army Medical Center, Washington, D. C., where they are assisting Lieutenant Colonel Paul F. Russell with some special entomological work.

The following men have recently transferred to the Sanitary Corps of the United States Army from other branches of the service: Second Lieutenant Albert W. Buzicky, formerly of the University of Minnesota and Second Lieutenant Sidney J. McCrory, formerly of the Bureau of Entomology and Plant Quarantine. These men will be engaged in entomological work in the Sanitary Corps.

List of Entomologists in the Armed Forces, Public Health Services and Other Fields of War Effort[1]

(This information is far from complete. Additions and corrections are being received daily. The Secretary would appreciate additional names and information. A second list will be published later in the year. Dates indicate date of latest information.)

*Abramitis, Walter W., 170 Boston Ave., Hillside, N.J. Dec. 1942 Cpl. 32387137, Det. Med. Dept., Sta. Hosp., Camp Sibert, Ala.

*Abrams, W. W., East Islip, N.Y. Dec. 1942. In the Army

Adams, John H., Jr., B.E.P.Q., San Antonio, Texas

*Adams, Lloyd E., St. Louis, Mo. Dec. 1941. In Hawaii

Aitken, Thomas, Capt., U.S.A., Ent. & Paras., Division Lab., San Juan, P.R.

Alexander, Donald H., B.E.P.Q., Corpus Christi, Tex.

Allee, John, B.E.P.Q., Chico, Calif.

Allen, Merle W., Coffeyville, Kans. June 1942. Capt., U.S.A.

Allen, Robert Ward, Iowa State College, Ames. Dec. 1942. Gunnery Sch. Co. C, 6 Baty., Ft. Knox, Ky.

Allison, Glenn R., B.E.P.Q., Escanaba, Mich.

Amen, Clark R., B.E.P.Q., Walla Walla, Wash.

Anderson, G. George, B.E.P.Q., Brownsville, Tex.

Anderson, Carol, 4436 Josephine, Denver, Colo. Ensign, U.S.N.R.

Anderson, Lorin, Sn. Corps, Fort Robinson, Ark.

Andrews, Justin M., Lt. Col., Overseas

Applewhite, Kermet N., B.E.P.Q., New Orleans, La.

*Apt, Albert C., Wynnewood, Pa. Lt., C.W.S.

*Arant, Frank S., Auburn, Ala. Capt., Sta. Hosp., Camp McCain, Grenada, Miss.

Armstrong, Robert L., Mass. State College, Amherst. Spring, 1942. 1st Lt., Sn. Corps

Armstrong, William Bruce, Iowa State College, Ames. Dec. 1942. O.S.C. #13, Fort Sill, Okla.

Avery, Phillip, U. of Fla., Gainesville, Lt., Infantry

Aufranc, Clarence W., B.E.P.Q., St. Louis, Mo.

Augustson, Gustaf F., (1943), 1st Lt. Sn. C., U. S. A., Carlisle Barracks, Pa.

Averson, A. Cooke, Iowa State College, Ames. Dec., 1942. 2nd Lt., 601½ E. Juan Linn, Victoria, Tex.

Aykroyd, Wesley, Mass. State College, Amherst. Summer 1941. 2nd Lt., Armored Force

Babers, Frank H., B.E.P.Q., Beltsville, Md. Jan., 1941. Lt. Col., 260th Coast Art.

Badman, Cecil S., B.E.P.Q., Berkeley, Calif.

*Bailey, Stanley F., Davis, Calif. Nov. 1942. Lt., U.S.N.R., Naval Air Station, Pensacola, Fla.

*Baker, A. W., Guelph, Ont. Feb. 1943. Lt. Col., Royal Canadian Naval Volunteer Reserve

Baker, Fred C., Ithaca, N.Y. Nov. 1942. Capt., Sn. Corps, Sanitary Officer in Charge, Pecos Air Field, Tex.

Ball, Eldon, Corvallis, Ore. Oct. 1942. 2nd Lt., Field Art.

Barclay, J. M., Dept. of Agr., Ottawa, Can. Jan 1940. 32nd–34th Battery, Royal Canadian Art.

*Barcus, David F. March, 1941. 1st Lt., Co. D, 176th Inf., South Post, Fort Myer, Va.

Barnes, R. C., U. of N. C., Raleigh. June 1942. Malaria Control in War Areas, Jacksonville, Fla.

Barnett, Frank L., B.E.P.Q., Pensacola, Fla.

Barnett, Herbert C., Ithaca, N.Y. Nov., 1942. Sgt., Div. of Par. & Trop. Med., Army Med. School, Washington, D.C.

*Barrett, William L., Jr., B.E.P.Q., Menard, Tex.

Bassett, Thomas S., Iowa State College, Ames. Dec., 1941. Ensign, U.S.N., Pacific Area.

Baumgartner, F. M., A. & M. College, Stillwater, Okla.

Beacher, J. H., Univ. of Del., Newark. Jan. 1942. Pvt.

*Becnel, Irwin J., April 1942. Lt., U.S.A. A.P.O. 251, Hq. Co., 6th Armored Inf., c/o Postmaster, New York City

Beier, R. L., U. of Cal., Riverside. Jan. 1942. Hq. Squad, 41st Bomb. Group, Hammer Field, Fresno, Cal.

Belkin, John N., Ithaca, N.Y. Nov. 1942. Lt., Sn. Corps, M.D.R.P., M.P.T.C., Camp Robinson, Ark.

Bell, Vernon A. V., Mass. State College, Amherst. March 1941. 1st Lt., Sn. Corps

Bench, Bill, B.E.P.Q., Columbus, Ohio

*Benton, Curtis, 1216 Ball St., Lafayette, Ind. Cpl. U.S.A., Med. Corps, Purdue Univ. ('43).

Bertagnalli, A. A., Madison, Wis. Lt., 877 Chem. Co., Barksdale Field, La

Bevin, Wendell, Expt. Sta., Fort Collins, Colo. Col., Art, U.S.A.

Bewick, Laurence F., A. & M. College, Stillwater, Okla. Aug. 1942, Sgt., O.T.S., Macon, Ga.

*Bibby, F. F., Smithsville, Miss. Jan. 1943. C.Ph.M., U. S. Naval Hosp., Pensacola, Fla.

*Bickley, William E., Norfolk, Va. Feb. 1943. Lt., U.S.P.H.S. Reserve

Biederman, Fred R., B.E.P.Q., Ft. Collins, Colo. Capt., Field Art., Fort Sill, Okla.

*Bigham, J. T., 181 Columbia St., Chester, S.C. Jan. 1943. 1st Lt., Sn. Corps. Overseas

*Billings, Samuel C., B.E.P.Q., Beltsville, Md. July 1942. 1st Lt., Sn. Corps, Overseas (1943).

Bills, Robert W., B.E.P.Q., Urbana, Ill.

Birkett, T. E., U. of Mo., Columbia, Mo.

*Blanton, F. S., Ithaca, N.Y. March 1943. Lt., Sn. Corps, Camp Chaffee, Ark.

Blomstron, Roy, B.E.P.Q., Oakland, Calif.

Blood, Everett G., U. of Minn., Minneapolis. Staff Sgt., Med. Det., 323rd S.T.R., Ft. Benning, Ga.

Boardman, Edw. T., 1st Lt., U.S.A., Med. Replacement Pool, Wash., D.C.

Bodenstein, William G., Ithaca, N.Y. Nov. 1942. Lt., U.S.A., A.C., Foreign service

Bofill, Miguel A., B.E.P.Q., Fajardo, P.R.

*Bohart, Richard M., U. of Calif., Berkeley. Dec. 1942. Ensign, U.S.N., Malaria Control, Marine Barracks, New River, N.C.

Bohm, Richard O., Mass. State College, Amherst. 1941. Ensign, U.S.N.

Bonnell, Daniel E., Corvallis, Ore. Aug. 1942. 1st Lt., Sn. Corps

Booth, Edwin W., U. of Fla., Gainesville. Lt., Art., U.S.A.

[1] Members of the AAEE are indicated by the asterisk.

*Bowen, Myles F., Spanish Fork, Utah. Sept. 1942. Cadet, Co. "F," Regiment of Cadets, Edgewood Arsenal, Md.
Boyd, George, Colo. Expt. Sta., Fort Collins. Capt., U.S.A.
Bragdon, K. P., U. of Fla., Gainesville. Lt., Art.
Brewer, Bradley G., B.E.P.Q., Pittsburgh, Pa.
*Brewer, E. G., B.E.P.Q., Bloomfield, N.J.
*Bridges, Lester, State College, Miss. Capt. A.A.F., Pre-Flight School, Maxwell Field, Ala.
*Bronson, Harry E., c/o H. G. Taylor, 305 Post Office, Newport News, Va. June 1942. Lt. (j.g.), U.S.N.R.
*Bronson, Arthur H., U. S. Rubber Co., New York. Jan. 1943. U.S.M.C., O.C.S., Parris Island, S.C.
Brown, Alanson D., B.E.P.Q., Lubbock, Tex.
Brown, Dwight C., B.E.P.Q., Fredericksburg, Va.
Brown, F. Martin, Colo. Springs, Colo.
*Brown, Harry E., Univ. of Mo., 1st Lt., Sn. Corps, U.S.A., Carlisle Barracks, Pa.
Brownlee, J. Milton, U. of Fla., Gainesville. Lt., Art., U.S.A.
*Brubaker, Ross W., 17 N. Blvd., Richmond, Va. Feb., 43. Lt. (j.g. , U.S.N.R. Gunner on merchant ship. Atlantic Area.
Brunson, Madimore, B.E.P.Q. Dec. 1942
Burke, Leo J., B.E.P.Q., New York.
Burks, B. D., Urbana, Ill. 1st Lt. Sn. Corps, U.S.A. 12th Malaria Survey Unit, A.P.O. 3658, c/o P.M., New York ('43).
Bucher, G. E., Dept. of Agr., Ottawa, Can. 1942. 4 mos. compulsory military training, R.C.A.T.C.
Bruck, Fred H., B.E.P.Q., Sonora, Calif.
*Bunn, Ralph W., B.E.P.Q., Washington, D.C. June 1941. Major, Sn. Corps, 1st Med. Gen. Lab., Ft. Houston, Tex.
Burge, Theodore A., B E.P.Q., Brookings, S.D.
*Burgess, Emory D., Moorestown, N.J. 1941, Sn. Corps, Sta. Hosp. Camp Claiborne, La.
Burhanna, A. L., Purdue Univ., Lafayette, Ind. Air Force, Panama
Burks, B. D., 123 Natural Resources Bldg., Urbana, Ill. Feb. 1943. 1st Lt., Sn. Corps, 12th Malaria Survey Unit, A.P.O. 3658, c/o P.M., New York
Bushing, Edward W., U. of Ill., Urbana. March 1943. Cpl., U.S.A., Med. Dept., Hammer Field, Calif.
*Buzicky, Albert W., 512 Montrose Lane, St. Paul, Minn. Cpl. U.S.A., Hammer Field, Fresno, Calif. ('43)

Carson, Nathan B., B.E.P.Q., Orlando, Fla.
Cain, Charles A., B.E.P.Q., Bloomfield, N.J.
Calvert, E. G., Dept. of Agr., Ottawa, Can. June 1940. Pilot Officer, R.C.A.F.

*Cameron, Donald, Ithaca, N.Y. Navigator, R.C.A.F., Killed in action over Malta

Cameron, J. MacBain, Ent. Lab., Annapolis Royal, N.S., Flying Officer, #5 T.S., R.C.A.F., Belleville Ont.
Cameron, John, Expt. Sta., Fort Collins, Colo.
Campau, E. J., Alto, Mich. Dec. 1942. Pvt., A.S.N. 36411020, 3rd Pl., C.C., 101st Med. Trng. Bat., Camp Robinson, Ark.
*Carpenter, Stanley J., 2601 N. Grant St., Little Rock, Ark. Major, Sn. Corps, Fort McPherson, Ga.
Cass, R. B., A. & M. College, Stillwater, Okla. Dec. 1942. Somewhere in the tropics
Cash, Walter, B.E.P.Q., Yakima, Wash.
Chamberlain, Roy W., Expt. Sta., Bozeman, Mont. Dec. 1942. Pvt., Med. Det., S.C.U., 1968, Fort Douglas, Ariz.
Chamberlin, W. J., Corvallis, Orc. May 1941. Major, Air Corps
Chapman, Thomas P., B.E.P.Q., Laredo, Tex.
Chowning, R. K., Purdue Univ., Lafayette, Ind. Aug. 1942, Cpl., Fitzsimmons Gen. Hosp., Denver, Colo.
*Chubb, Henry S., Winter Park, Fla. June 1942. Pfc., 4th Malaria Survey Unit, Camp Harrihan New Orleans, La.
Clark, James A., St. Ent. Office, Indianapolis, Ind. Spring, 1942. Pfc., A.S.N. 35261325, 1st Bn., H. W. Det., 128 Inf., A.P.O. 32, c/o Postmaster, San Francisco, Calif. (In Australia)
*Clark, John R., Riverside, Calif. Jan. 1941. Lt., Field Artillery
Clarke, John F. G., Ithaca, N.Y. Feb. 1942. 1st Lt., Q.M.C.
*Cochran, James H., DuPont Co., Wilmington, Del. Dec. 1942. C.W.S., Huntsville, C.W. Depot, Huntsville, Ala.
Coffin, Lillard B., B.E.P.Q., San Antonio, Tex.
Cohen, Aaron, Mich. St. Coll., East Lansing. Army Air Corps
Cole, Kendrick C., Mass. State Coll., Amherst. 1941 Pvt., Quartermaster Corps
*Condon, Walter, Corpus Christi, Tex. Naval Air Service, Corpus Christi, Tex.
Connell, Walter A., U. of Del., Newark. Jan. 1942. 1st Lt., Sn. Corps
Connell, William, Med. Sec., 1st Lt., 1580 S.U., Camp Campbell, Ky.
Connely, Al., Mother Hill, Sacramento, Calif.
Conner, T. J., Jr., B.E.P.Q., Oxford, N.C. June 1942. U.S.A.
Conradi, Karl, Manchester, Ga. Dec. 1941. 1st Lt., Art., Foreign Service
Cooke, O. B., Agr. Exp. Sta., New Haven, Conn. Major, Provost Marshal, 43rd Div.
Copenhafer, L. M., Manhattan, Kans. 2nd Lt., Post Utilities Office, Fort Leonard Wood, Mo.
Cowan, Frank A., B.E.P.Q., Waco, Tex.
Cox, Randolph, B.E.P.Q., Fredericksburg, Va.
*Crane, Philip S., Berkeley, Calif. Feb. 1942. Aviation Cadet, P.S. Squadron, Box 500, Wayne, Pa.,
*Christenson, Leroy D., B.E.P.Q., San Bernardino, Calif. Sn. Corps. Overseas
Crissman, William I., Mich. St. Coll., East Lansing. Ensign, U.S.N., c/o P.M.
*Crosthwait, S. L., 1941. Major, Air Force
Crowell, John C., B.E.P.Q., Oakland, Calif.
Crumb, Samuel E., Jr., B.E.P.Q., Puyallup, Wash. June 1941. Lt., U.S.A.
Cunningham, Glen R., Iowa State College, Ames. Dec. 1942. Cpl., Trade Test Center, St. Louis.
Curtiss, Alfred C., B.E.P.Q., Brookings, S.D.
Curtiss, Charles, Lt., U.S.A.
*Cushing, Emory C., B.E.P.Q., Washington, D.C. Nov. 1942. Major, Sn. Corps (British Isles)
Cullen, William J., B.E.P.Q., Lawrenceville, N.J.
Cyr, Bennis J., B.E.P.Q., Thornhurst, Pa.

Daggy, Richard H., B.E.P.Q., New Smyrna Beach, Fla. Ensign (M.C.) U.S.N.R., M Division, N.A.B. Button, F.P.O., San Francisco, Calif.
*Dahm, Paul A., U. of Illinois, Urbana. Civilian Instructor in Meteorology, Chanute Field, Ill.
*Dahms, R. G., B.E.P.Q., Lawton, Okla. Dec. 1942. U.S.A., Fort Sill, Okla.

*Daniel, Derrill M., 77 Maple St., Geneva, N.Y. Major, U.S.A. Tunisia (March, 1943)
*Daniels, Charles H., c/o L. J. Bottimer, 4329 Claggett Rd., Hyattsville, Md. July 1942. 1st Lt., Sn. Corps, Sta. Hosp., Fort Jackson, S.C.
Darling, Thomas G., Rich. M.S.C., East Lansing, Mich. 51st Air Base Squadron, A.C. Gunnery School, Harlingen, Tex.
Davis, C. Marion, Iowa State College, Ames. Dec. 1942. 39th Gen. Hosp., Camp Edwards, Mass.
Davis, Max Edward, Iowa State College, Ames. Dec. 1942. Coast Guard Station, Gov. Island, Alameda, Calif.
Deal, John C., Jr., Purdue Univ., Lafayette, Ind. 2nd Lt., U.S M.C., Southwest Pacific
*Dean, H. A., McAllen, Tex. Feb. 1942. U.S.N., Ph.M. 3/c, U.S.S. *President Adams*, c/o Fleet P.O., San Francisco, Calif.
DeCapria, A., Agr. Expt. Sta., New Haven, Conn. 1st Lt., Military Police
*DeCoursey, J. D., Beltsville, Md. Lt., U.S.N.R., M.C., Naval Air Sta., Trinidad, B.W.I. ('43)
DeLeon, Donald, B.E.P.Q., Lafayette, Ind. Co. B., 103 Bn., M.R.T.C., Camp Robinson, Ark.
Dekle, George W., U. of Fla., Gainesville. Lt., Art., U.S.A.
Dews, Samuel G., Major, Sn. Corps, U.S.A., Ft. McPherson, Ga.
*Dicke, Robert J., Madison, Wis. Ensign, U.S.N.R. Naval Med. Sch., Bethesda, Md.
Dike, Clyde E., B.E.P.Q., Bloomfield, N.J.
*Dobkin, Irving B., Univ. of Illinois, Urbana. U.S.N.R., Insp. Div., 1414 Field St., Hammond, Ind.
Doell, William R., Jr., B.E.P.Q., St. Paul, Minn.
Dominick, Clarence B., Chatham, Va. 1st Lt., Sn.C., Sta. Hosp., Camp Davis, N.C.
Dondero, Louis A., B.E.P.Q., Pittsburgh, Pa.
*Dorsey, Carl K., Gulfport, Miss. Ensign, U.S.N.R., Camp Peary, Williamsburg, Va. ('43)
*Dorst, Howard E., Logan, Utah. Apr. 1941. Major, Sn. Corps, Camp Robinson, Ark.
Dorward, K. Melvin, B.E.P.Q., Boise, Idaho
Douglas, C. R., Dept. of Agr., Ottawa, Can. Jan. 1942. Navigation Instructor, R.C.A.F.
Douglas, Guy McD., B.E.P.Q., Harlingen, Tex.
Douglass, William J., B.E.P.Q., Norfolk, Va.
*Doutt, Richard L., Riverside, Calif. Apr. 1941. Lt. (j.g.) U.S.N.R., Air Force, Pacific Area.
Dow, Richard, Lt., Sn. Corps, Sta. Hosp., Camp Cooke, Calif.
DuBreuil, R. K., Dept. of Agr., Ottawa, Can. Oct. 1941. R.C.A.F.
Duncan, Madison M., B.E.P.Q., Blacksburg, Va.
Dupree, Minter, Experiment, Ga. Aug. 1942. Pvt., Inf., Fort McPherson, Ga.
Dutky, Samson R., B.E.P.Q., Moorestown, N.J.

Eagan, Francis T., B.E.P.Q., Florala, Ala.
*Eaton, Charles B., Berkeley, Calif. Dec. 1942. Cpl., Co. E., Bar. 245, M.D.E.T.S., O'Reilly Gen. Hosp., Springfield, Mo.
Elberfield, Richard B., Mass. State College, Amherst 1941. Pvt., Coast Art.
*Elliott, Charles E., Apr. 1942. 1st Lt., Cav., Box 802, Ancon, Canal Zone
Embody, Daniel R., Ithaca, N.Y. Nov. 1942. Ensign, U.S.N.R.
Emerson, K. C., A. & M. College, Stillwater, Okla. Capt., U.S.A. (reported missing from Philippines, probably prisoner of the Japanese)
Enns, Wilbur R., Univ. of Mo., Columbia
Erickson, Eldon A., Univ. of Calif., Riverside. Jan. 1941. Aviation Cadet, Army Navigation School, Honda, Tex.
Ernest, Paul S., B.E.P.Q., Denver, Colo.
Evans, Howard, Ithaca, N.Y. Nov. 1942. Pvt., Engrs.
Evans, Robert E., Mass. State College, Amherst
Ezri, Harold A., B.E.P.Q., Wooster, Ohio

Farleman, M. Q. East Lansing, Mich. F.R.T.C., 19 Tr. Rgt., 89 Bn., Camp Roberts, Calif. (1943)
Fassing, W. W., Univ. of Del., Newark. Oct. 1942. Capt., Sn. Corps, Camp Livingston, La.
Fate, Lester R., B.E.P.Q., Bloomfield, N.J.
*Fay, Richard W., Univ. of Illinois, Urbana. U.S.P.H.S., New Orleans, La.
*Fels, Eugene, 5049 Franklin Ave., Los Angeles, Calif. Dec. 1942. U.S.A.
Finney, Gerald M., B.E.P.Q., Berkeley, Calif.
*Fisk, Frank W., 1510 21st St., Washington, D.C. Capt., U.S.A., Med. Sect., S.O.S., A.P.O. 886, New York. In India ('43)
Flanagan, George, Mass. State College, Amherst. 1941. 2nd Lt., Coast Art.
Fletcher, Vernon A., B.E.P.Q., Oakland, Calif.
Fluke, B. C., Madison, Wis. 77th Gen. Hosp., Hammond Gen. Hosp., Modesto, Calif.
Fluno, John A., St. Health Dept., Jefferson City, Mo. U.S.P.H.S.
*Fogarty, Daniel B., Univ. of Fla., Gainesville. 2nd Lt., 691 F. A. Bn., Fort Sill, Okla. (1943)
Ford, Lloyd, Agr. Expt. Sta., Fort Collins, Colo.
Fowler, John M., Mass. Sta. College, Amherst. 1941. Capt., Cavalry (Japanese prisoner)
Fox, Irving, Iowa State College, Ames. 1st Lt., Sn. Corps., A.P.O. 846, c/o P.M., New York.
Franclement, John G., Ithaca, N.Y. Nov. 1942. Lt., Sn. Corps, Ft. Benjamin Harrison, Ind.
Frederick, Edgar H., B.E.P.Q., Thomasville, Ga.
*Freeborn, Stanley B., Berkeley, Calif. June 1942. Lt. Col., Sr. Surgeon, Malaria Control in War Areas, 505 Volunteer Bldg., Atlanta, Ga.
Freeland, A. L., Ithaca, N.Y. Nov. 1942, Lt., U.S.A.
Freele, Hugh P., Ithaca, N.Y. Pvt., U.S.A.
Friley, Charles E., Jr., Iowa State College, Ames. Dec. 1942. Lt., 66th Field Art. Pine Camp, N.Y.
*Fritz, Roy F., U.S.P.H.S., 605 Volunteer Bldg., Atlanta, Ga. (1943)
*Fronk, William D., Ogden, Utah. Dec. 1942, 2nd Lt., S.M.D.T. School Dept., Fitzsimmons Hosp., Denver, Colo.
*Furr, Garland L., B.E.P.Q., Brownsville, Texas. June 1941, Capt., Army Air Corps

Gallaway, Harry E., B.E.P.Q., Elko, Nev.
Gelfand, Henry, Ithaca, N.Y. Pvt., U.S.A., Foreign Service
Gerberg, Eugene, Ithaca, N.Y. Nov. 1942. U.S.P.H.S., Mosquito Control Work, Ark.
Gerlach, C. F., Madison, Wis. U.S.P.H.S., Springfield, Ill.
*Gerhardt, Paul, Riverside, Calif. July 1942. Ensign, U.S.N.R., N.T.S., Hanover, N.H.
Gerry, Bertram I., Capt., Sn. Corps, Replacement Pool, Camp Jos. T. Robinson, Ark.
*Gibson, K. E., 108 N.D St., Toppenish, Wash. Aug. 1942. Army Air Corps Res., Glider School
Gibson, Lester, Expt. Sta., Fort Collins, Colo. Army Air Corps
*Gilbert, Irwin H. March 1942. Capt., Sn. Corps, 6th Service Command Lab., Fort Sheridan, Ill.
*Gillies, K. D., 2736½ W. 42nd St., Los Angeles, Calif. Lt., C. W. Prod. Div., Edgewood Arsenal, Md.

*Girardeau, J. H., Jr., McRae, Ga. March 1942. 1st Lt., Inf., A.P.O. No. 957 c/o P.M., San Francisco.
Glenisky, Neil O., B.E.P.Q., Pierce, Idaho
Goldberg, Robert, Mar. 1943. Ensign, U.S.N.T.S., Patton Hall, Princeton, N.J.
Gordon, William N., Ithaca, N.Y. Lt. (j.g.), Med. Corps, Naval Air Station, Corpus Christi, Tex.
Gould, John D., Mass. State College, Amherst. Summer, 1941. 2nd Lt., Coast Art.
Graham, Howard, Corvallis, Ore. Oct. 1942, U.S.N.R.
Graham, John G., B.E.P.Q., Gainesville, Fla.
*Graham, Owen H., B.E.P.Q., Yuma, Ariz. Summer, 1942. 1st Lt., Sn. Corps, Fourth S.C., Camp Hoffman, N.C.
*Granek, Irving, 1364 Sterling Pl. Brooklyn, N.Y. 1st Lt., 224th M.P. Co., Fort Dix, N.J.
*Gray, H. E., Dept. of Agr., Ottawa, Can. July 1942, Agr., Pilot Officer, R.C.A.F.
Green, Garvin, Ithaca, N.Y. Nov. 1942. Sergeant, U.S.A., Foreign Service
Green, William, Expt. Sta., Fort Collins, Colo. Capt., Artillery
Greesit, J. Linsley (Prisoner of Japanese at Canton, China)
*Griffiths, James T., Ames, Iowa. Sn. Corps., U.S.A. ('43)
*Grundman, Albert W., Salt Lake City, Utah. 1st Lt., Sn. Corps, Camp San Luis Obispo, Calif. (Mosquito Abatement Work)
Guralnick, E., Mass. State College, Amherst. 1942. Capt., U.S.A., Medical Corps
*Gurney, Ashley B., Washington, D.C. Apr. 1942. 1st Lt., Station Hospital, Camp Crowder, Mo.
Guthrie, John B., B.E.P.Q., Miami, Fla.

Haag, Ralph, U.S.N.R., Midshipman's School, Columbia Univ., New York. ('43)
Hadley, Benjamin, Mass. State College, Amherst. Summer, 1942. 2nd Lt., U.S.M.C.
Haeger, James P., Univ. of Fla., Gainesville. Sgt., Medical Corps, Camp Blanding, Fla.
Hall, David G., B.E.P.Q., Washington, D.C. July 8, 1942. Capt., Sn. Corps
Hall, Gaird G.
Hall, George W., B.E.P.Q., Pharr, Tex.
Hall, Robert E., Mass. State College, Amherst. Summer, 1941. 1st Lt., A.A.F.
Hall, R. T., Agr. Exp. Station, New Haven, Conn. Pvt., Infantry
Halliday, H. H., Madison, Wis., Petty Officer, Navy Recruiting Office, Milwaukee, Wis.
Hanley, Robert, Mass. State College, Amherst. 1942. Ensign, U.S.N.R.
Handen, Sylvan Leonard, Univ. of Maryland, Pvt. U.S.A. (1943)
Hannum, Thomas Edward, Iowa State College, Ames. Dec. 1942, Sgt. A.E.F., Northern Ireland
Hansen, James W., Univ. of Calif., Berkeley. Merchant Marine, San Francisco
Hardy, D. Elmo, Utah State College, Logan. 1st Lt., Station Hosp., Morrison Field, West Palm Beach, Fla.
Harris, H. H., Madison, Wis., 37318882, Q.M.C. Det., Bushnell Gen. Hosp., Brigham City, Utah
Harriss, Ernest G., Manhattan Kan. 2nd Lt., Co. D., 1st S.T.R., Fort Benning, Ga.
Harrison, Harry Iowa State College, Ames. Dec. 1942. U.S.C.G. Acad., New London, Conn.
Hart, Thomas A., Lt., Sta. Hosp., Camp Gordon, Ga.
Harwell, Rufus T., Tifton, Ga.
*Haug, G. W., Kelowna, B.C.
Haugen, Archie E., B.E.P.Q., Dishman, Wash.
Hawkins, Robert M., Iowa State College, Ames Dec. 1942. 116th Med. Rgt., Fort Lewis, Wash.
*Heaton, Robert R., Terminex Co., Indianapolis, Ind. 1st Lt., Sn. C., 15 Gen. Med. Lab., Ft. Sam Houston, Tex. (1943)
Heller, Isidore, Ithaca, N.Y. Nov. 1942. Sgt., Med. Corps, Plattsburg, N.Y.
Helwig, Edwin R., Univ. of Pa., Phila., Jan. 1943. 1st Lt., Sn. Corps, Camp Pickett, Va.
Haniford, Bruce, Purdue, Univ., Lafayette, Ind. 2nd Lt., 317th Inf., 80 Div., Camp Forrest, Tenn.
Henry, James R., B.E.P.Q., State College, Miss.
*Hensill, G. S., Calif. Spray-Chem. Corp., Richmond, Calif. Nov. 1942. Lt. H-V (S) U.S.N.R., Main Dispensary, Naval Air Station, Jacksonville, Fla.
*Herms, W. B., Univ. of Calif., Berkeley. Jan. 1942. Lt.-Col., Dept. of Military Sanitation, Army Medical Field Service School, Carlisle Barracks, Pa.
Herreman, Dermont E., Jr., B.E.P.Q., Scottsbluff, Neb.
Hershberg, Bernard, Mass. State College, Amherst. Aug. 1942. Pvt., Q.M. Corps
Hertig, Marshall, Major, Sn. Corps., Med. Replacement Center, Wash., D.C.
Hicks, Ellis Arden, Iowa State College, Ames. Dec. 1942. Lt., Co B., 320nd 2-M Bn., Fort Lewis, Wash.
*Hill, Clarence H., Greensboro, N.C., 1st. Lt., Sn. Corps., Camp Pickett, Va.
*Hill, Sam O., Univ. of Fla., Gainesville. April 1941. Capt., Sn. Corps, Camp Stewart, Ga.
Hinkle, Gallen, Fort Robinson, Ark., Sn. Corps
*Hinman, Frank G., Univ. of Idaho, Moscow. Nov. 1942. Pvt., Co. C., 57th Med. Tng. Bn., Camp Barkeley, Tex.
*Hitchcock, John D., U. S. Bee Culture Laboratory, Laramie, Wyo. April 1942. Pvt., 4th Platoon, 300th Gen. Hosp., Camp Forrest, Tenn.
Hitchon, J. L., Dept. of Agri., Ottawa, Can. May 1941. Pilot Officer, R.C.A.F.
Hobbs, G. A., Dept. of Agr., Ottawa, Can. Dec. 1941. Sgt., 19th Field Rgt., 63 Battery, R.C. Art.
*Hoffman, Wm. E. (Prisoner of Japanese at Canton, China)
*Hofmaster, R. N., B.E.P.Q., Box 1101, Twin Falls, Idaho. March 1942. Coast Guard
Holbert, H. L., B.E.P.Q., Waco, Tex.
Holdworth, Robert, Mass. State College, Amherst. Fall, 1941. Lt. (j.g.), U.S.N.R.
Holstrom, Hugh R., B.E.P.Q., Easton, Pa.
*Holway, R. T., So. Duxbury, Mass. Dec. 1942. Ensign, U.S.N.R., Naval Med. Center, Bethesda, Md.
Hoogstraal, Harry, March 1943. Fourth Service Command Laboratory, Atlanta, Ga.
*Horsfall, W. R., Fayettesville, Ark. Feb. 1943. 1st Lt., Sn. Corps, U.S.A., Med. Replacement Pool, Camp Grant, Ill.
Hosbrook, Lawrence F., B.E.P.Q., Chico, Calif.
Hostetter, John I., Iowa State College, Ames. Dec. 1942. Aviation Cadet, Flight 1, 43E; Dorr Field, Arcadia, Fla.
Howard, Goerge E. B.E.P.Q., Chelan, Wash.
Howe, Wayne, Colorado Expt. Sta., Fort Collins. 1st Lt., Sn. Corps, U.S.A., Med. Replacement Pool, Wash., D.C.
Howell, Colton, B.E.P.Q., Stoneville, Miss.
Huey, Ralph L., Ithaca, N.Y. Nov. 1942, Ensign, U.S.N.R.

Hull, J. B., B.E.P.Q. Lt. (j.g.), U.S.N.R., Malaria Control Lab., Marine Barracks, Hadnot Point, New River, N.C.
Hunt, Paul, A. & M. College, Stillwater, Okla. Dec. 1942. Lt., Air Force (Co-Pilot)
Hunter, Robert P., Mass. State College, Amherst. 1942. Lt. (j.g.), U.S.N.R.
*Hunter, William P., Univ. of Fla., Gainesville. 1st Lt., 893rd T.D. Bn., Camp Hood, Tex.
*Hupper, Theodore, 4312 N. Pershing Dr., Arlington, Va. Chief of Placement, Office of Chief of Air Corps, War Department, Washington, D.C.
Hurlbut, H. S., Ithaca, N.Y. Nov. 1942. Lt., S.G.O. U.S. Navy Med. Corps, Marine Barracks, Vieques Island, P.R.
*Hutchins, Ross E., State College, Miss. Lt. (j.g.), U.S.N.R.
Hutton, G. S., Purdue Univ., Lafayette, Ind. April 1942. Co. K, 2nd Regt., The Q.M. School, Camp Lee, Va.

Ingram, Ralph, Mass. State College, Amherst. 1942. Pvt., Coast Art.
*Irvine, Milton B., 626 N. Electric Ave., Alhambra, Calif., Nov. 1942. Ensign, U.S.N.R.

Jackson, Calvin W., B.E.P.Q., San Antonio, Tex.
James, Edwin F., B.E.P.Q., Fresno, Calif.
*Jefferson, R. N., Agr. Expt. Sta., Blacksburg, Va. 1st Lt., C.A.C., Battery D, 386th C.A. Bn. Camp Edwards, Mass.
Jeffery, Arthur R., B.P.I., Harrisburg, Pa. Feb. 1942, 2nd Lt., Fort Benning, Ga.
*Jenkins, Lee, 107 Whitten Hall, Univ. of Missouri, Columbia. Sn. Corps
*Jennings, H. E., 7417 Stoney Island, Chicago, Ill. Lt., U.S.N.R., Nav, (S) 216 W. Jackson Blvd., Chicago, Ill.
Johnson, Arthur S., B.E.P.Q., San Francisco, Calif.
Johnson, David O., Univ. of Maryland, College Park. 1942. Ensign, U.S.N.R.
Johnson, Bryan T., Mass. State College. Amherst. 1942, Lt., U.S.A. Air Force
Johnson, Harry, Mass. State College, Amherst. 1941. Capt. Armored Force, Recreational Officer
*Johnson, Thomas W., Deerfield, Mass. 1942. Pvt., Air Force
Johnston, Daniel R., Iowa State College, Ames. Dec. 1942. Lt., U.S.A.
Jones, Alonzo L., Office of the State Ent., Augusta, Me. Oct.. 1942. Ensign, U.S.N.R.
*Jones, George D., Univ. of Missouri, Columbia
Jones, Jack D., Fort Sill, Okla. 1st Lt., Artillery
Jones, Joseph W., Jr., Av. Cadet A.A.C., P. O. Box 173, Newbern, Tenn.
Jordan, Austin R., B.E.P.Q., Lubbock, Tex.
Joyce, J. W., Dept. of Agr. Ottawa, Can. June 1942. Staff Sgt., Can. O.T.C.

Kagan, Abbot, A. & M. College, Stillwater, Okla. 2nd Lt., Air Corps, Selma Field, Ala. (Teaching R.A.F. Students)
*Kartman, Leo, 940 N. Alma Ave., Los Angeles, Calif. 10th Malaria Survey Unit, N.O.S.A., New Orleans, La.
*Keck, Chester B., B.E.P.Q., Honolulu, T.H. 1942. 1st Lt., 21st Inf., P. O. Box 340, Honolulu
Keller, John C., Camp Barkeley, Tex. Medical Corps
Kelley, Sam G., Uvalde, Tex. Capt., U.S.A., San Antonio, Tex.
Kent, Ellis, Corvallis, Ore. June 1942. Army
Kerwick, Michael F., Iowa State College, Ames. Dec. 1942. Class 42-A Corps, Adv. Flying School, Stockton, Calif.
*Kido, George, Poston General Hosp., Poston, Ariz.
*Kidwell, Arthur S., Sanders Exterminating Co., Baltimore, Md. Oct. 1942. 1st Lt., Sn. Corps, S.T.S., M.R.T.C., M.D.R.P., Camp Robinson, Ark.
*King, Edwin W., Mass. State College, Amherst. Mar. 1943. Cpl., Med. Corps, Camp Sanitation Officer, Camp Edwards, Mass.
*King, W. V., Orlando, Fla. Lt.-Col., Med. Corps Overseas. (March, 1943)
Klahr, James R., B.E.P.Q., Moscow, Idaho
Klostermeyer, Edward C., Univ. of Nebraska, Lincoln. Air Forces, Cpl., Base Weather Sta. Twenty-nine Palms, Calif.
Klots, Alexander B., Capt., Sn. Corps, Carlisle Barracks, Pa.
Knapp, Virgil R., Purdue Univ., Lafayette, Ind. Summer 1941. Ph. M. 3/c, Camp Perry Dispensary, Building 1109, U.S.N.T.S., Great Lakes, Ill.
*Knight, Kenneth L., Univ. of Illinois, Urbana. Navy 600, c/o Fleet P. O., San Francisco, Calif. Mar. 1943. Lt. (j.g.), U.S.N.R. (Malaria control work in South Pacific)
Knigin, Samarath. Malaria Lab., Office of Sector Surgeon, A.P.O. 868, P.M., New York
Krafchick, Bernard, Ithaca, N.Y. Nov. 1942. Pvt., Camp Wheeler, Ga.
Krall, Jack Louis, Iowa State College, Ames. Dec. 1942. Ensign, U.S.N.R., Ketchikan, Alaska
Kramer, Sol. Cpl., M.D.P.S.S.S., Army Medical School, Washington, D.C.
Kretschmar, G. Ensign, 803 Custom House, U.S.O.Q., Philadelphia, Pa.
Kropf, Fred H., Colo. Expt. Sta., Fort Collins
Kroll, Jack L., B.E.P.Q., Asheville, N.C.
Krombein, K. V., B.E.P.Q., Washington, D.C. May 1942. 1st Lt., Sn. Corps., 1318th Service Unit Post Hdqs., Camp Pickett, Va.
Kuhn, Lee Wallace, Iowa State College, Ames. Dec. 1942. 10th Field Hosp., Camp Bowie, Tex.
Kuitert, Louis C., Lt., Sn. Corps, Army Base, Dyersburg, Tenn.

Ladeburg, C. F., Kilgore Seed Co., West Palm Beach, Fla. Dec. 1942. Cpl., Co. D, Reception Center, Camp Blanding, Fla.
Lafleur, Vincent, Mass. State College, Amherst
Laidlaw, H. H., Madison, Wis., Pvt., Co. D., 56th Med. Tng. Bn., Camp Barkeley, Tex.
Lamansky, Kenneth W., B.E.P.Q., St. Joseph, Mo.
Landers, Horace J., B.E.P.Q., Bloomfield, N.J.
*Landrum, John M., B.E.P.Q., 306 Rule Bldg., Amarillo, Tex. Capt. 50 Arm'd. Inf., APO 256, Camp Cooke, Calif.
Lanham, U. N., Pvt., 4th Mapping Squadron, March Field, Calif.
Laudani, Hamilton, Mass. State College, Amherst. June 1942, Pvt., U.S.A., Sn. Corps
Langemack, Vernon W., B.E.P.Q., Yakima, Wash.
Lawler, William, Ithaca, N.Y. Nov. 1942. U. S. Public H. S. of U. S. Navy
Lawrence, Mason, Ithaca, N.Y. Nov. 1942, U.S.N., Apprentice Seaman
*Lawson, F. R., B.E.P.Q., Box 1101, Twin Falls, Idaho. Aug. 1942.
Leach, Gerold E., B.E.P.Q., San Antonio, Tex.
Leland, Maurice T., Mass. State College, Amherst. Summer, 1942. 2nd Lt., U.S.A., Cavalry

Leland, Justin W., 1st Lt. Sn. Corps, U.S.A., Med. Replacement Pool, Camp Grant, Ill.
Levine, Norman D., Iowa State College, Ames. Dec. 1942. Lt., La Garde Gen. Hosp., New Orleans, La.
Lewis, Fred, Fort Collins, Colo.
*Lieux, Davidson E., July 1942. 1st Lt., U.S.A., Sn. Corps, Lawson Gen. Hosp.
Limbacker, T. F., Iola, Kan. Major, U.S.A.
*Livingston, Erksine M., B.E.P.Q. New Orleans, La. Feb. 1942. 1st Lt., Sn. Corps
Loeffler, E. S., Berkeley, Calif. Chemist, Mare Island Navy Yard, Calif.
Long, A. C., Ithaca, N.Y. Nov. 1942. U. S. Navy, Med. Res., McGill, University
Lopp, Oscar V., Indianapolis, Ind. Jan. 1943. Lt., Sn. Corps. Ft. Belvoir, Va.
Lourie, Raymond E.
Lowry, William L., B.E.P.Q., Presidio, Tex.
*Ludvik, George F., Univ. of Illinois, Urbana. Mar. 1943. Station Hospital, Camp Van Dorn, Miss.
*Lund, Horace O., Athens, Ga. May 1942. Lt. (j.g.), U.S.N.R., Naval Air Station, Elizabeth City, N.C. (Malaria control officer)

*MacCreary, Donald, Newark, Del. April 1942. Lt. (s.g.), U.S.N.R., Mosquito Control Work, Overseas, Jan. 1943.
McBurnie, Horace V., B.E.P.Q., Whittier, Calif.
*McAlister, Harold J., B.E.P.Q., Washington, D.C. May 1941, Capt. Hq. 111 Corps, Fort McPherson, Ga.
*McCauley, W. E., 123 Natural Resources Bldg., Urbana, Ill. Mar. 1943. 1st Lt., February, 1943. Overseas Duty in Pacific Area
McClain, Elmo F., Univ. of North Carolina, Raleigh. Feb. 1942. Hendrick's Field, Sebring, Fla.
McClelland, Richard T., B.E.P.Q., Dishman, Wash.
*McCollom, Albert E., W. Saint John, N. B., Can. Dec. 1940
McConnell, H. S., College Park, Md., 1st Lt., Sn. Corps, Camp Pickett, Va. (1943)
McCrary, S. J., 819 Gladstone Blvd., Shreveport, La. ('43). 2nd Lt., Sn. Corps, U.S.A.
McDonald, E. D., Ithaca, N.Y. Nov. 1942. Pvt., Ski Troops
McDonald, F. L., Manhattan, Kan. 1st Lt., Co. D, 103rd Inf., A.P.O. 3193, c/o P.M., San Francisco.
McGough, Francis T., U.S.N., Ph. M. 2/c, 3407 Canal St., New Orleans, La.
*McGough, James M., Morton, Miss. Capt., Foreign Service
McGuire, Judson U., Iowa State College, Ames. Dec. 1942. Sgt., O.F.T.
*McGregor, Theodore, Weslaco, Texas, 1st. Lt., Sn. Corps, U.S.A. ('43). Fort Dix, N.J.
McIntyre, H. N., Dept. of Agr., Ottawa, Can. Feb. 1940, Royal Canadian Navy
McKay, Francis Paul, Iowa State College, Ames. Dec., 1942. Lt., U.S.A. Air Corps
McKee, John A., B.E.P.Q., Bloomfield, N.J.
McKenna, George F. Feb., 1941. Lt., Student Officer, Armored Force School, Fort Knox, Ky.
McLain, George F., Jr., B.E.P.Q., Coolidge, Ariz.
McLean, H. Hubert, B.E.P.Q., Poughkeepsie, N.Y. Pvt., U.S.A. Air Force, June 1942
McLeod, J. H., Dept. of Agr., Ottawa, Can. Dec. 1941, R.C.A.F.
McPhee, A. W., Dept. of Agr., Ottawa, Can., Dec. 1941, R.C.A.F.
Macy, Harry D., Mich. State College, East Lansing. 1st Lt., Camp Carson, Colo.
Maehler, Kenneth, Fort Collins, Colo.
Magner, J. Marshall, Urbana, Ill. 14th Malaria Survey Unit. N.O.S.A., New Orleans, La. ('43)
*Mailen, T. H., Bartlesville, Okla. Sept. 1942. Pvt., 37224464, 4th Service Command, Med. Lab., Ft. Mcpherson, Ga.
Malone, Milton S., Houston, Tex. Lt., Army
Mangrum, James F., Pvt., 183 Gen. Hosp., Fort Sill, Okla.
*Manis, H. C., Univ. of Idaho, Moscow. July 1942 Air Transport Service, Moscow, Idaho
Manzelli, Manlie A., Agr. Expt. Sta., New Brunswick, N.J. Oct. 1941. 1st Lt., Sn. Corps, 4th Service Command, Carrabelle, Fla.
Maratea, Domenic J., B.E.P.Q., Moorestown, N.J.
March, Ralph B., Univ. of Ill., Urbana. 2nd Lt., Army Air Base, Thermal, Calif. ('43)
Markos, Basil G., Durham, N.H. Feb. 1943. 1st Lt., U.S.A., Med. Dept., Camp Shelby, Miss.
Marks, Irwin, Corvallis, Ore. Jan. 1942, Ensign, U.S.N.R.
Martin, D. F., College Station, Tex., 1st Lt., M.R.T.C., Camp Joseph T. Robinson, Ark.
Martin, E. C., Dept. of Ent. Univ. of Manitoba, Winnipeg, Can. May, 1942. Probationary Sub-Lieutenant, Canadian Navy
Marucci, Phillip E., B.E.P.Q., Charlottesville, Va.
*Mason, Horatio C., B.E.P.Q., Columbus, Ohio. Lt. Col., U.S.A. Inf.
Mason, W. D., 151 W. 11th Ave., Columbus, Ohio. April, 1941. Major, Air Borne Infantry
Massey, Calvin L., Expt. Sta., Fort Collins, Colo. Sn. Corps
Matheny, Gallasi E., B.E.P.Q., Blacksburg, Va.
Mattlage, William F., B.E.P.Q., Columbus, Ohio
*Maxwell, K. E., Shell Oil Co., Martinez, Calif. Lt. (j.g.), U.S.N.R., Malaria Control, Naval Medical Center, Bethesda, Md.
Maynard, Joseph H., B.E.P.Q., Bloomfield, N.J.
*Meek, Roy C., Dept. of A. and I., Baton Rouge, La. May 1942. Corp. 56 Evac. Hosp., A.P.O. 304, c/o P.M., Leesville, La.
Merrill, Leland G., Mich. State College, East Lansing. U.S.A., Fort Sill, Okla.
Merritt, James M., Tobacco By-Products, Louisville, Ky. Capt., 2nd Proc. Bn., J.B.A., Pakenham Sta., New Orleans, La.
*Messenger, Kenneth, Sept. 1942. Lt., U.S.N.R., Navy Yard, Washington, D.C.
*Messenger, Kenneth, 820 Insurance Exchange Bldg., Denver, Colo. Sept. 1942. Lt., U.S.N.R., Navy Yard, Washington, D.C.
*Middkelauff, W. W., Ithaca, N.Y. Nov. 1942. Capt., Sn. Corps, Ft. McPherson, Ga. (Medical entomology)
*Miller, Lawrence I., Blacksburg, Va.
Milliron, Herbert E., Purdue Univ., Lafayette, Ind. Sept. 1942. 1st Lt., Sn. Corps, Fort Knox, Ky.
Mitchell, James I., B.E.P.Q., Fort Collins, Colo.
Moehler, Floyd, Madison, Wis. Lt., Camp Breckenridge, Ky.
Mohr, Carl O., 123 Natural Resources Bldg., Urbana, Ill. Aug. 1942. 1st Lt., 1570 Service Unit, Med. Section, Camp Breckenridge, Ky.
Moore, William M., B.E.P.Q., Garden City, Kan.
Moorman, Robert E. Iowa State College, Ames. Dec. 1942. Inducted at Camp Dodge, Iowa
Morgan, L. W., B.E.P.Q., Lake Park, Ga.
Morley, P. M., Dept. of Agr., Ottawa, Can. June 1942. Capt. Forestry Corps
*Morris, Orville D., B.E.P.Q., Houston, Tex. Sept. 1942.

Morse, Freeman E., Mass. State College, Amherst. June 1942. Pvt., Air Force
Moulden, Leonard H., Kansas State College, Manhattan. Ensign, U.S.N.R., Aviation Base, Olathe, Kan.
Mowry, Paul, Corvallis, Ore. Sept. 1942. 2nd Lt., Infantry
Munroe, Eugene C., Ithaca, N.Y. Nov. 1942. Royal Canadian Air Force
Munson, Sam C.
Murphy, Milledge, Jr., B.E.P.Q., Atlanta, Ga. Lt., U.S.A., Infantry

Nalewaik, William J., B.E.P.Q., Bridgeport, Conn.
Nardy, Robert, Ithaca, N.Y. Nov. 1942. Pvt., U.S.A.
Neilson, C. L., Dept. of Agr., Ottawa, Can. Feb. 1942. Royal Canadian Corps of Signals
Nelson, Ivory A., B.E.P.Q., White Haven, Pa.
Nelson, Russell W., B.E.P.Q., Spokane, Wash.
Nerney, Norbert J., B.E.P.Q., New Haven, Conn. Pvt., U.S.A., Battery A, 60th Bn., Field Art., A.P.O. #9, Fort Bragg, N.C.
*Newkirk, M. R., 1522½ Highland St., Columbus, Ohio. Jan. 1943. Pvt., U.S.A.
Newsom, Leo D., Ithaca, N.Y. 1942. Pvt., U.S.A.
*Noble, M., Dept. Agr. Ottawa, Can. Oct. 3, 1942, R.C.A.F.
Nicholson, R. A., Corvallis, Ore. Sept. 1942.
*Nolan, Willis J., Beltsville, Md. May 1942. Capt. 702nd M.P. (E 1), Pikesville, Md.
Nolin, D. J., Jr., Ithaca, N.Y. Nov. 1942, Lt., U.S.A., Foreign Service
Nonamaker, Harold A., Smith Center, Kan. Feb. 1942. 1st Lt., Co. A, 16th Inf., A.P.O. 1208, c/o P.M.
*Nottingham, J. O., Lawrence, Kan. Feb. 1942. 1st Lt., C.A.C., Personnel Adjutant
Nutting, William B., Mass. State College, Amherst. Fall, 1942. Pvt., U.S.A.
Nye, W. P., Utah State College, Logan. Capt., U.S.M.C., 3d Tank Bn., Camp Elliott, San Diego

Olson, Howard C., Univ. of North Carolina, Raleigh. March 1942. 2nd Lt., Co. 1., 307th Inf., 77th Div., Fort Jackson, S.C.
Olson, Richard D., Iowa State College, Ames. Dec. 1942.
Oman, P. W., B.E.P.Q., Washington, D.C. Oct. 1942. 1st Lt., Sn. Corps
*Ortega, John J., Univ. of Calif., Riverside. Sept. 1942. Ensign, U.S.N.R., Defense School, Treasure Island, San Francisco, Calif.
Osthopp, Herbert, Colorado Expt. Sta., Fort Collins. Quartermaster Corps, U.S.A.
*Owen, Wm. B., Univ. of Wyoming, Laramie ('43). Capt., Sn. Corps, Carlisle Barracks, Pa.
Owen, Woodrow C., B.E.P.Q., New Orleans, La.

Park, Andrew R., Univ. of Illinois, Mar. 1943, Cpl. U.S.A., 56 Evacuation Hosp., Ft. Sam Houston, Tex.
*Parker, Lawrence B., B.E.P.Q., Moorestown, N.J.
Parker, W. LeRoy, Univ. of Illinois, Urbana. Mar. 1943. Ensign, U.S.N., Amphibian Training Base, Little Creek, Va.
*Parnell, Charles L., Box 909, Brownsville, Tex. June, 1941. Lt., Inf.
Parsons, Carl T., Cpl. Med. Det., Hendricks Field, Sebring, Fla.
Parsons, Charles E., B.E.P.Q., Bloomfield, N.Y.
*Partlow, C. O., 1200 Morton St., Lafayette, Ind. Jan. 1942. Lt., A.A.F., Navigation School, Hondo, Tex.
*Patton, J. R., West Union, Ohio. Jan. 1943, N. A. Cadet. U.S.N.R., Naval Flight Prep School, I-B-4 Stuyvesant Hall, Rm. 229, Delaware, Ohio
Paus, Arthur L., Mass. State College, Amherst. Nov. 1942. Pvt., U.S.A.
Pauy, Edmund E., Dept. of A. and I., Baton Rouge, La. April 1942. Lt., U.S.A., Port of Embarkation, New Orleans, La.
Payner, Martin M., Camp Bowie, Tex. Medical Detachment, U.S.A.
Pederson, Calvin E., Michigan State College, East Lansing. Ensign, U.S.N., Malarial Control Office, Naval Air Station, Trinidad, B.W.I.
Peeples, Russell C., Univ. of Fla., Gainesville. Lt., Co. A, 3rd Bn. Trng., Camp Wheeler, Ga.
Pence, Albert L., Jr., B.E.P.Q., Spokane, Wash.
Penrod, Kenneth E., Iowa State College, Ames. Dec. 1942. Lt., Material Div. Air Corps, Dayton, Ohio
Peters, Richard F., ('43). 1st Lt., Sn. Corps, U.S.A. Overseas Duty, Malaria Survey
Peters, Harold T. 1st Lt., Sta. Hosp. Camp Pickett, Va.
Petrakis, Manuel M., Univ. of Illinois, Urbana. Mar. 1943. Chanute Field, Ill. Extension Hospital
Pettit, Lincoln C., Baldwin, L.I., N.Y.
Pierpont, Roger L., 6712 Windsor Mill Road, Woodlawn, Md. April, 1942. 1st Lt., Sn. Corps, Sta. Hosp., Fort Benning, Ga.
Pierce, Robert A., Iowa State College, Ames. Dec. 1942. Pvt., Med. Det., 168 Rgt., A.P.O. 1001, c/o P.M., New York
Pillar, Alvin C., U.S.N., Deck Officer
Pitts, George, Mass. State College, Amherst
Platts, Norman G., B.E.P.Q., Eng. Sanitarian, Malaria Control in War Areas, Atlanta, Ga.
Plasket, Edwin L., B.E.P.Q., Moorestown, N.J.
Porter, John E., Urbana, Ill. Sr. Eng. Aide, Malaria Control in War Areas, Wash., D.C.
Portman, R. W., Colorado Expt. Sta., Fort Collins, 2nd Lt., Sn. Corps, El Paso, Texas
Post, Claude Y., B.E.P.Q., New York
*Post, R. L., Bonneville, Oregon. Aug. 1942. Coast Guard A.S.(R.R.), Bonneville
Potts, Merlin, Colorado Expt. Sta., Fort Collins
*Powers, George E., Ardmore, Pa. Ensign, Naval Medical School, Bethesda, Md.
Pratt, C. R., B.E.P.Q., Hardin, Mont.
Pratt, Harry, San Juan, P.R. Control of Malaria in Extra-Cantonment Areas
Prebble, J. S., Dept. of Agr., Ottawa, Can. Aug. 1940. Captain, Forestry Corps
Pritchard, A. Earl, San Juan, P.R. Control of Malaria in Extra-Cantonment Areas
Proctor, James W., B.E.P.Q., Charlottesville, Va.
Putnam, L. G., Dept. of Agr., Ottawa, Can. Aug. 1942. Lt., Canadian O.T.C.

Quay, Thomas L., Univ. of North Carolina, Raleigh. June, 1942. Malaria Control in War Areas, Elizabeth City, N.C.

Rachels, Leroy, Oklahoma A. & M. College, Stillwater. 1st Lt., U.S.A.
Ramsey, Thomas, Lt., U.S.N.
Randolph, T. B., B.E.P.Q., Waco, Texas
Rasmussen, Bill, Corvallis, Oregon. Sept. 1942, Pvt., Med. Corps

Rebstock, J. D., Ithaca, N.Y. Nov. 1942. Douglas Aircraft Corp., Foreign Service

Reed, John P., Maine Expt. Sta., Orono. Cpl., U.S.A., 39th Gen. Hosp., A.P.O. 3284, c/o P.M., San Francisco, Calif.

*Reed, W. D., B.E.P.Q., Richmond, Va. July, 1942. Lt. C.W.S., Post Hq. Edgewood Arsenal, Md. in charge of sanitation and pest control.

Rees, Bryant E., B.E.P.Q., Washington, D.C. 1st Lt., Sn. Corps, Overseas Duty, Malaria Control (1943)

Rehn, John W. H., Ithaca, N.Y. Nov. 1942. Douglas Aircraft Corp., Foreign Service

Remington, Richard, Univ. of Florida, Gainesville. Pvt., U.S.M.C.

Rhodes, W. C., Oklahoma A. & M., Stillwater

Richmond E. Avery, Amherst, Mass. Nov. 1942. Major, C.W.S., 23rd and D, Wash., D.C.

Riegel, G. T., Urbana, Ill. Aug. 1942. 1st Lt., Sn. Corps, Feb. 1943. 12th Malaria Survey Unit., A.P.O., 3658, c/o P.M., New York

*Riehl, Louis, A. Rockefeller Inst. of Med. Res., 66th St. and N.Y. Ave., New York

Rings, R. W., B.E.P.Q., Wooster, Ohio

*Riss, John S., 3501 S. 33 Ave., Minneapolis, Minn. July 1942. SEABEES, C.C.M., U.S.N.R., Navy 8525, c/o Fleet P.O., New York

*Ritchie, Calvin L., 1st Lt. Sn. Corps, U.S.A. Med. Replacement Pool, Camp Parkeley, Texas

Roan, Clifford, Sgt., U.S.A., Urbana, Ill. Instr. Meteorology Weather Observation, Base Weather Station, Chanute Field, Ill.

Roberts, Howard L., 1st Lt., Sn. Corps, U.S.A., Army Med. Center, Wash., D.C.

Roberts, R. A., Big Springs, Tex. Capt., Sn. Corps, Army Officers Training Bn. Carlisle Barracks, Pa.

Roberts, Raiford A., B.E.P.Q., Gulfport, Miss.

Roberts, Raymond, Univ. of Nebraska, Lincoln. July 1942. 1st Lt., Sn. Corps, MRTC, OCS, Camp Barkeley, Tex.

*Roberts, Reed S., Utah State College, Logan. Jan. 1942 A/c, Sq. 2, Flight A., U. S. Air Forces Tr. Det., Harvey Parks Airport, Sikeston, Mo.

Robertson, Lee J., B.E.P.Q., Houston, Tex.

Rockstein, Morris, Pvt. Base Weather Office, Bradley Field, Conn.

Rohar, J. A., B.E.P.Q., Brookings, S.C.

Roherds, J. E., B.E.P.Q., Wenatchee, Wash.

Rose, Harold D., Mass. State College, Amherst. Ensign, U.S.N., Dept. 1941

Rose, Robert, Davis, Calif. Sept. 1942

Roseboom, Kenneth N., B.E.P.Q., St. Paul, Minn.

Roselle, Robert E., Univ. of Missouri, Columbia. Sept. 1942

Ross, E. S., Lt. Sn. Corps, 8th Service Command Lab., Ft. Sam Houston, Tex.

*Roth, Roger W., Ithaca, N.Y. Nov. 1942. Signal Corps

Roth, Louis M., Laboratory, 4th Corps Area, Ft. McPherson, Ga.

Rounds, Dean, Mass. State College, Amherst. 1941. Lt., Air Force, U.S.A.

*Rowell, John O., Univ. of N.C., Raleigh. March 1942. Capt., O-282497, 438 Bomb. Sq., APO 520, c/o P.M., New York

Roy John T., B.E.P.Q., Florala, Alabama

Russ, Fred A., Ithaca, N.Y. Nov. 1942. Lt., U.S.A., Foreign Service

Ryan George S., Pvt. Btry. C. 399 C.A.; B.B. Bn. Sault Ste. Marie, Mich.

*Ryberg, M. E., U. S. Naval Academy, Annapolis, Md. Nov. 1942. Lt., c/o Supervisor of Shipbuilding, U.S.N., Manitowoc, Wisconsin

*Safro, Victor I., 225 Central Park West, New York City. Capt. Army Air Corps

Sanders, Louis T., B.E.P.Q., Clemson, S.C.

Sarton, Milton H., B.E.P.Q., Hoboken, N.J.

Saunders, J. E., Dept. of Agr., Ottawa, Can. Jan. 1941, R.C.A.F.

Saveraid, Joye H., Iowa State College, Ames. Dec. 1942. U.S.N.R., 714 202 Cadet Regt., U.S.N.A.S., Jacksonville, Fla.

Scharlach, A. B., B.E.P.Q., McAllen, Texas

Schell, S. C., Univ. of N.C., Raleigh. 1942. Malaria Control in War Areas, Raleigh, N.C.

Schenker, Hansen, Mass. State College, Amherst. Summer, 1941. 2nd Lt., Armored Force

Schlesselman, C. H., Iowa State College. Dec. 1942

Schmidt, Walter H., B.E.P.Q., Elko, Nev.

*Schoof, H. F., Univ. of N.C., Raleigh. 1942. Malaria Control in War Areas, Raleigh

Schrack, Harold, Univ. of Illinois, Urbana. Radio Operator, N.D.O. Section, Allegon, Mich.

Schroeder, Philip M., B.E.P.Q., Milwaukee, Wis.

Schumacker, D. E., Iowa State College, Ames. Dec. 1942. 40th Div., A.P.O., Fort Lewis, Wash.

Schweet, Richard S., Iowa State College, Ames. Dec. 1942. A.A.F.

*Scott, David B., Jr., 701 Alameda St., Altadena, Calif.

*Scott, Roger, Corvallis, Ore. 1942. Cpl. Med. Det.

Scott, Thomas G., Iowa State College, Ames. Dec. 1942. Lt., Office S-4, Army Base, Port of Embarkation, North Charleston, S.C.

*Secrest, John P., 3707 Parkwood St., Brentwood, Md. Dec. 1942. U.S.N.T.S., Great Lakes, Ill.

Sennette, W. F., B.E.P.Q., Lubbock, Tex.

*Shafer, Ralph W., B.E.P.Q., Wenatchee, Wash.

*Sharp, Silas, Ruston, La. Dec. 1942. Capt., 35th Field Art., Camp Blanding, Fla.

*Sherman, Franklin, III, Michigan State College, East Lansing. 1st Lt., Sn. Corps, Sta. Hosp., Camp Chaffee, Ark.

Shewell, G. E., Dept. of Agr., Ottawa, Can. May 1940. Lt., Royal Canadian Artillery

*Shields, S. E., New Smyrna Beach, Fla. Jan. 1943. 1st Lt., (0484036), Sn. Corps, Key West, Fla.

Sigsbee, Harold, J., B.E.P.Q., Poughkeepsie, N.Y.

*Siddall, Cameron College Station, Tex. 1st Lt., Sn. Corps, Co. "D," 61st Med. Trng. Bn., Camp Barkeley, Tex.

Slagle, Lowell E., Univ. of Florida, Gainesville. Lt., A.A.F.

Slater, Eben A., Iowa State College, Ames. Dec. 1942. U. S. A.A.F., MacDill Field, Fla.

Slater, James A., B.E.P.Q., Urbana, Ill. Ensign, U.S.N.R., N.T.S., Ohio State Univ., Columbus. (43)

Slocum, J. Byron, B.E.P.Q., Chico, Calif.

Smith, D. S., Dept. of Agr., Ottawa, Can. Apr. 1941. Flying Officer, R.C.A.F.

*Smith, Edward H., 17 Ferry St., Abbeville, S.C. 1st Lt., 36th Tr. Bn., Camp Croft, S.C.

Smith, Elmer, Mass. State College, Amherst. Aug. 1942. Pvt., Med. Corps

Smith, Frederick E., Mass. State College Amherst. Fall, 1942. Pvt., Sn. Corps

*Smith, George F., Air Corps

Smith, Gordon, Ithaca, N.Y Nov. 1942. Capt., Sanitary Officer with General Stillwell's Army in China

Smith, Jack D., B.E.P.Q., New York, N.Y.

Smith, James N., B.E.P.Q., Newport News, Va.

Smith, Lawrence F., Iowa State College, Ames. Dec. 1942. Naval Reserve (Med. School), Chicago, Ill.
Smith, W. R., B.E.P.Q., State College, Miss.
Snead, Edwin I., Iowa State College, Ames. Dec. 1942. U.S.N.R.
Solomon, Marvin, Univ. of Md., College Park, 1942. Ensign U.S.N.R., Island Parole, Norfolk, Va.
*Soraci, F. A., Trenton, N.J. A.U.S., (Apr. 1943)
Spear, Philip J., Mass. State College, Amherst. 1942. Pvt., Eng. Corps
*Spencer, Herbert, Univ. of Florida, Gainesville. March 1941. Lt.-Col., Sn. Corps, School of Military Government, Charlottesville, Va.
*Spicer, Wm. J., B.E.P.Q., 1st Lt. Sn. Corps, U.S.A., Med. Replacement Pool, Camp, Barkeley, Texas
Stains, George S., Utah State College, Logan. Ensign, U.S.N., Dist. Med. Office, 14th Naval District, Pearl Harbor, Honolulu, T.H.
*Stanton, Elvyn R., 2654 Temple Ave., Puenta, Calif. June 1942.
Staples, Robert, Mass. State College, Amherst. 1942. Cpl., Med. Corps, Boston, Mass.
*Starker, Charles H., Jennings Lodge, Oregon. Nov. 1942. Cpl. Sn. Corps, Hq. Det. 3rd Sn. Tng. Bn., S.C.R.T.C., Camp Kohler, Sacramento, Calif.
Steady Clarence J., B.E.P.Q., Dishman, Wash.
*Stearns, L. A., Univ. of Delaware, Newark. June 1942. Major, Sn. Corps, Overseas (Persian Gulf)
Stiff, Howard, Mass. State College, Amherst. 1941. 2nd Lt., U.S.A.
Stevens, Leroy C., Ithaca, N.Y. Nov. 1942. Lt. U.S.A., Foreign Service
Stimola, Joseph, Colorado Expt. Sta., Fort Collins. U. S. Navy
*Stone, Philip C., Univ. of Missouri, Columbia. 1st Lt., Sn. Corps, March 1943. Sanitation Officer, Norfolk Army Base, Norfolk, Va.
Stone, Philip V., B.E.P.Q., Madison, Wis.
*Strickland, E. H., Univ. of Alberta, Edmonton. May 1942. Lt. Col., Canadian Army Basic Training Center, Prince of Wales Armory, Edmonton
Sugerman, Bernard B., Univ. of Illinois, Urbana. March 1943. Sgt. U.S.A., Med. Det., A.A.F.T.S., Lincoln Air Base, Lincoln, Neb.
*Sullivan, William N., Jr., B.E.P.Q., Beltsville, Md. April 1942. Lt., U.S.A.
Suib, S. Lincoln, Ithaca, N.Y. Nov. 1942. Pvt. U.S.A.
Swanson, John L., B.E.P.Q., Oakland, Calif.

*Talbert, E. Leland, Box 277, Laredo, Tex. April 1942. U.S.A.
Tarshis, Ivin, Corvallis, Ore. Sept. 1942. U.S.A.
Taylor, Glenn J., B.E.P.Q., Oakland, Calif.
Taylor, Gordon S., Iowa State College, Ames. '42. Lt., Bat. D. 52 F.A. Tr. Bn., Fort Sill, Okla.
Taylor, Lawrence, Colorado Expt. Sta. Fort Collins
Teller, L. W., Univ. of Maryland, College Park. Pvt., Fort Myer, Va.
Thatcher, T. O., Capt. (0-305-165) Hq. 495 C.A. and B. A.P.O. 860 P.M., New York
Thompson, Clarence G., Corvallis, Ore. Oct. 1940. Lt. Infantry
*Thompson, R. W., Ont. Agr. College, Guleph. Feb. 8, 1943. Royal Can. Nav. Vol. Res.
Thurlow, Donald, Mass. State College, Amherst. 1941. Corp., Army Air Force
Ting, Peter, B.E.P.Q., Berkeley, Calif. Ensign, U.S.N.R.
Tinkham, Ernest R., 1st Lt., Sn. Corps, U.S.A., Boca Raton Field, Fla. (Malaria Control)
Tinkham. Robert E., Univ. of Arizona, Tucson. July 1942. 1st Lt., Sn. Corps
*Tischler, Nathaniel, 1st Lt. Sn. Corps, U.S.A., Med. Replacement Pool, Wash., D.C.
Tittle, Homer B., B.E.P.Q., Dilley, Texas
*Toffaleti, James P., Univ. of Florida, Gainesville. Technician 4/gr. U.S.A., Fourth Corps Area Laboratory, Ft. McPherson, Ga.
Tolsa, Pedro, B.E.P.Q., Mayaguez, P.R.
*Traub, Robert, Univ. of Illinois, Urbana, In Command, 9th Malaria Survey Unit., N.O.S.A., New Orleans. ('43)
Traugman, Carl G., Iowa State College, Ames. Dec. 1942. Ph. M., U.S.N.T.S., Great Lakes, Ill.
Treneman, Robert A., Iowa State College, Ames. Dec. 1942. Capt., Fort Bragg, N.C.
Triggs, Robert, Mass. State College, Amherst. Summer, 1942. Midshipman, U.S.N.
Tulloch, George, Mass. State College, Amherst. Nov. 1942. Lt., (s.g.) U.S.N., Sanitary Work
Tuttle, Donald M., Michigan State College, East Lansing. O.T.S., Carlisle, Pa.

Uhler, Lowell D., Ithaca, N.Y. 1942. Lt., U.S.A.
Underhill, A. H., Ithaca, N.Y. Nov. 1942. Lt., U.S.A.
*Usinger, R. L., Davis, Calif. U.S.P.H.S.

Van Steenburgh, W. E., Dept. of Agr., Ottawa. May 1940. Lt. Col., 3/47 Field Battery, Royal Art.
Venable, J. B., Univ. of Florida, Gainesville. Sgt., U.S.A., Med. Corps, Camp Blanding, Fla.
Vincent, Richard, Mass. State College, Amherst. 1941. Lt., U.S.M.C.
Vincent, Rufus, H., Univ. of Maryland, College Park. Aug. 1942. 1st Lt., Sn. Corps, Camp Blanding, Fla.
*Vinzant, J. P., Oct. 1942. Pvt., Chem. Sec., Hq. & Hq. Sq., 15th A.D.Q., Duncan Field, Tex.

Wagner, George B., B.E.P.Q., Manhattan, Kan. 1st Lt., U.S.A. Flying School, Sq. 810, Sioux Falls, S.D.
Wagner, Robert M., B.E.P.Q., Morristown, N.J.
*Wagner, William E., 123 Garden Rd., Columbus Ohio. Feb. 1942. 1st Lt., 14th Arm. Field Art. Bn., A.P.O. 252, Fort Bragg, N.C.
Wakefield, Walter, Mass. State College, Amherst. 1942. Pvt., Mechanic, Air Force
Wallace, George E., Cpl., Co. K, E.R.S. Students Bn., T.D. School, Camp Hood, Tex.
Wallace, Robert B., Iowa State College, Ames. Dec. 1942. Pvt., Aberdeen Proving Grounds, Md.
Walker, Henry, Mass. State College, Amherst. 1941. Capt., Air Force, Ground Officer
Wall, William J., Mass. State College, Amherst. Summer, 1942. 2nd Lt., Cavalry
Ward, A. B., Agr. Expt. Sta., New Haven, Conn. Pvt., Inf.
Washburn, Richard, Michigan State College, East Lansing. 2nd Lt., U.S.A., C. Battery, 165 F.A. Bn., A.P.O. 939, Seattle, Wash.
*Watson, Reginald C., 150 Baronne St., New Orleans, La. Aug. 1942. Field Artillery
Watts, C. N., B.E.P.Q., Orlando, Fla.
Watts, T. J. B.E.P.Q., Rio Grande City, Texas
*Weatherby, A. B., Dept. of A. and I., Baton Rouge, La. April 1942. Malaria Control at Vieques and Ensanada Honda, P.R.
*Webb, Joseph E., Univ. of Florida, Gainesville.

March 1941. Major, Sn. Corps, Sta. Hosp., Camp Blanding, Fla.
Webster, William A., Ithaca, N.Y. Nov. 1942. Civilian Pilots Training Corps, Ithaca
Wellhouse, William T., Iowa State College, Ames. Dec. 1942. Lt., Camp McCoy, Wis.
Wenzel, R. L., 1st Lt., Sn. Corps, 707th Med. Sn. C., Ft. Geo. G. Meade, Md.
Wessels, Conrad P., B.E.P.Q., Medford, Oregon
West, William, c/o Clay Lyle, State College, Miss
Weyl, Val E., Madison, Wis. Pvt., Hq. Co. (Prov. Co.) 2nd Arm'd Med. Bat., 9th Arm'd Div., Ft. Riley, Kansas
Whitcomb, Edward L., B.E.P.Q., Columbus, Ohio
White, L. T., Dept. of Agr., Ottawa, Can. June 1942. R.C.A.F.
*White, Richard O., College Park, Md. 1st Lt., Ft. Benning, Ga.
Whiteley, Edward J., Iowa State College, Ames. Dec. 1942. Capt., 32nd Med. Mb., Medical F.S.S., Carlisle Barracks, Pa.
Whittemore, Frederick E., Mass. State College, Amherst. Capt. Sn. Corps, U.S.A., Overseas Duty, Malaria Survey. ('43)
*Whittington, F. B., Univ. of Maryland, College Park. 1942. 1st Lt., Sn. Corps, Ft. Bragg, N.C.
Williams, Marlowe C., Iowa State College, Ames. Dec. 1942. Major, U.S.M.C.
Williams, Roger W., Univ. of Illinois, Urbana. March 1943. Ensign, Malariologist, U.S.N., Marine Tr. Base, New River, N.C.
Williamson, H., Dept. of Agr., Ottawa, Can. Capt., Canadian Army in England
*Wilson, John W., Wellston Air Depot, Macon, Ga. Lt., Army Medical Corps
Winburn, Temple F., B.E.P.Q., Manhattan, Kan. Major, Air Service, Independence, Kan
*Wingo, Curtis W., Univ. of Missouri, Columbia. Feb. 1942. S/Sgt., Adv. Tg. Sq., G.R.C. Rec. Area, Kutland Field, Albuquerque, N.M.
Winters, Earl, Michigan State College, East Lansing. 1st Lt., U.S.A., 601st Regt., C.A., (A.A.) Gen. Del., Phila., Pa.
Wood, Edward P., College Park, Maryland. Jan. 1943. Pvt., U.S.M.C., pl. 70, Recruit Depot, Marine Barracks, Paris Island, S.C.
*Woke, Paul A., 6126 54th Ave., Riverdale, Md. Lt. Navy 213, c/o Fleet P.O., New York. 1941
Wolfe, Homer R., B.E.P.Q., Spokane, Wash.
*Wollerman, E. H., Ohio State Univ., Columbus. Medical Administrative Corps
*Worthley, Harlan N., Penn. State College Major, C.W.S., Hq. and Hq. Co., Director of Schools, Replacement Training Center, Gadsden, Alabama
Wright, Robert S., B.E.P.Q., Union Gap, Wash.

Yant, Roger, Purdue Univ., Lafayette, Ind. June 1941. 87th Field Art. Bn., A.P.O., 829, c/o P.M., New Orleans, La.
Yoemans, Alfred H., B.E.P.Q., Washington, D.C. Aug. 1942. Pvt., U.S.A.
Yeringon, Albert P., Jr., B.E.P.Q., Okanagan, Wash.
*Yuill, Joseph S., B.E.P.Q., Berkeley, Calif. Lt. (j.g.), U.S.N.R., Ship's Co. June 1942. Naval Construction T.C., Camp Peary, Norfolk, Va.
Yunghans, Charles F., Manhattan, Kan. 2nd Lt., Air Force, Paine Field, Wash.

Zein, DeWitt, Ithaca, N.Y. Lt., Army Air Corps, Shaw Field, Sumter, S.C.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

PROCEEDINGS FOR THE YEAR 1942.

(Annual Meetings scheduled for New York, December 29, 30 and 31 Cancelled because of the War)

REPORT OF THE SECRETARY AND BUSINESS MANAGER

Membership in the Association now stands as follows:

Active members as of January, 1942	1,486
Total in Military Services carried as Active for duration	174
Resignations in 1942	26
Deceased in 1942	7
Reinstatements in 1942	8
New members as of March 15, 1943	125
Total active members as of March 15, 1943	1,576

Members serving in the Armed Forces and with the U. S. Public Health Service are listed separately as a tribute to them and as a notice to the public that entomologists are making the winning of the war of paramount importance. Entomologists have asked for no special consideration with respect to deferment, but they were included in a directive from the Selective Service authorities as constituting essential workers.

JOURNAL subscriptions totalled 2,119 at the time of the December issue. This includes 50 volumes the American Library Association has purchased to be held for distribution to libraries in War Areas after the war.

The War Work Questionnaire was prepared in this office and mailed out to all members. One thousand and fifty were returned to Dr. F. C. Bishopp, Chairman of the Committee on Military Entomology. A complete report of this committee appears elsewhere. It was a joint effort of the two societies.

In May the secretary sent out a letter in regard to letter balloting, and this provided a waiver from the membership which, if approved, would permit of balloting by mail in the absence of specific constitutional provision for such balloting. Of the 514 replies received, 500 were in the affirmative. This enabled the Executive Committee to order a letter ballot for the election of officers for 1943. The return of the ballot for election of officers indicated a willingness to transact business in that way, and caused many favorable comments from isolated members. A total of 974 ballots were returned.

The accounts of the Association are submitted in detail as certified by the auditor, and show a healthy condition of the funds despite the loss of revenue due to the effect of the war on memberships and subscriptions.

The wisdom of accepting rather than seeking advertisements has been justified by a continuance of advertising at approximately the same scale, despite the general reduction in this activity in other lines.

The cost of the JOURNAL per page has been kept down due to the very efficient work of the Editor. Even though our publisher has been under pressure from the government for "must work," the JOURNAL has appeared somewhat along the usual schedule. We should remember the present conditions under which the JOURNAL has to function, and subscribers are asked to be lenient in their judgment about delays.

The announcement of the Office of Defense Transportation made it essential that the annual meeting in New York be canceled. It is hoped that a meeting may be held next year. In fact, it seems almost imperative that a meeting be held, and plans are being made for the calling of a meeting somewhere in the Middle West. It is necessary that the meeting be held without any affiliation with other groups in order to keep down the size of groups travelling to the point selected, and in order that there may be less congestion in the hotels of the city selected.

During the past year the two societies have cooperated in many endeavors, the results of which appear in the reports of the various committees. It is highly gratifying that this close cooperation exists, and emphasizes the spirit of entomologists to increase the efficiency of entomological endeavors.

Elsewhere there is a report of the Special Committee on *Entoma*, which should go a long way to satisfy some diversity of opinion in regard to the manner of issuance of this very valuable publication. The fifth edition is now being prepared, and possibly there may be no need in the future for a change in policy.

ERNEST N. CORY
Secretary & Business Manager

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
FINANCIAL STATEMENT FOR THE FISCAL YEAR ENDED NOVEMBER 30, 1942
RECEIPTS AND DISBURSEMENTS

	TOTAL	JOURNAL	ASSOCIATION	INDICES I-V	INDEX VI	INDEX VII
Receipts:						
Subscriptions	$ 6,736.67	$6,736.67				
Advertising	488.90	488.90				
Reprints	1,684.91	1,684.91				
Back numbers	353.13	353.13				
Dues	2,724.35		$2,043.26		$ 450.09	$ 231.00
Sale of indices	191.60			$179.60	12.00	
Common names	99.85		99.85			
Bond Interest	25.00	12.50	12.50			
Total Receipts	12,304.41	9,276.11	2,155.61	179.60	462.09	231.00

Disbursements:						
Auditing and accounting fees	68.00	34.00	34.00			
Surety bond for secretary	12.50	6.25	6.25			
Safe deposit box rental	6.93		6.93			
Printing	6,509.90	6,509.90				
Engraving, drafting, etc.	635.57	635.57				
Editors' honorarium	450.00	200.00			250.00	
Assistant to the Editor	360.00	110.00			250.00	
Honorarium, Secretary & Business Manager	600.00	300.00	300.00			
Stenographic services, Secretary	167.50	83.75	83.75			
Clerical	102.43	44.57	57.86			
Traveling Expenses: E. N. Cory & Secretary	606.69		606.69			
S. B. Fracker	78.43		78.43			
Chas. Palm	16.90		16.90			
P. D. Sanders	15.97		15.97			
Committee: J. S. Houser	95.58	95.58				
L. M. Peairs	11.33	11.33				
E. F. Phillips	95.27	95.27				
Convention Expenses: Programs, badges	226.66		226.66			
Telegrams, J. Parker	11.00		11.00			
Branch Expenses: Cotton States	79.06		79.06			
Pacific Slope	35.98		35.98			
Postage, stationery & supplies	547.12	192.42	349.30		5.40	
Telephone & telegraph	23.90		23.90			
Express	12.13	4.67	5.55	1.91		
Bank service charges	10.37	5.18	5.19			
Refunds	27.85	24.85	3.00			
Check charged to account in error	3.00	1.50	1.50			
Total Disbursements	10,810.07	8,354.84	1,947.92	1.91	505.40	—
Excess of Receipts Over Disbursements	1,494.34	921.27	207.69	177.69	43.31*	231.00
Add: Balance, November 30, 1941	6,922.82	2,244.86	2,861.73	29.43*	1,617.16	228.50
Transfer of Balance, November 30, 1941					+228.50	−228.50
Balance, November 30, 1942	$ 8,417.16	$3,166.13	$3,069.42	$148.26	$1,802.35**	$ 231.00

This balance is represented by the following:

Prince Georges Bank & Trust Company (checking account)	$5,745.30
Cash on Hand (deposited December 1, 1942)	671.86
U. S. Defense Bonds, Series G (2½% interest)	2,000.00
	$8,417.16

* Indicates debit (deficit) balance.

** Invoice for printing Index VI amounting to $4,907.81 has not as yet been paid. This liability can readily be met by a transfer of funds from either the JOURNAL and/or the Association or from the Permanent Fund shown below.

STATEMENT OF PERMANENT FUND

Balance, November 30, 1941, as per previous report			$24,160.95
Income for the period:			
Interest received from securities		$292.50	
Interest received from savings deposits:			
Prince Georges Bank & Trust Co.	$59.51		
Franklin County Trust Co.	12.13		
		71.64	
Interest credited to book value of U. S. Bonds		300.00	
Total Income			664.14
Balance, November 30, 1942			$24,825.09

The balance is invested as follows:

Par Value	Securities	Market or Redemption Value	Book Value
$ 2,000	Province of Ontario, 5's		$ 2,000.00
2,500	U. S. Treasury Bonds, 3¼'s	2,578.00	2,484.00
3,000	U. S. Treasury Bonds, 2½'s	3,270.00	2,984.00
5,000	U. S. Savings Bonds, Series A	4,400.00	4,400.00
10,000	U. S. Savings Bonds, Series D	8,100.00	8,100.00
2,000	U. S. Defense Bonds, Series G	1,976.00	2,000.00
			$21,968.00
	Bank Deposits (Savings Accounts)		
	Prince Georges Bank & Trust Co. (2%)	$2,723.35	
	Unclipped coupons (Deposited December 29, 1942)	133.74	$ 2,857.09
	Balance of investments (as above)		$24,825.09

Dr. E. N. Cory, Secretary
American Association of Economic Entomologists January 8, 1943

Dear Dr. Cory:

I have made an examination of the accounts and financial records of the American Association of Economic Entomologists for the fiscal year ended November 30, 1942 and, without making a detailed audit of the transactions, have tested the accounting records of the association and other supporting evidence, by methods and to the extent deemed appropriate.

In my opinion the accompanying statements of receipts and disbursements of the association and the permanent fund present fairly the results of its operations for the fiscal period and the cash positions of its funds at November 30, 1942.

CHARLES L. BENTON, JR., *Certified Public Accountant*

REPORT OF THE NOMINATING COMMITTEE

(The following nominations were presented and sent out to the membership in the form of a letter ballot)

For—

President: CLAY LYLE, P. N. ANNAND, G. M. BENTLEY

First Vice-President: A. S. HOYT, F. H. LATHROP, CLAY LYLE

Executive Committee: F. L. THOMAS, A. S. HOYT

Program Committee: S. W. BILSING, F. L. THOMAS

Committee on Membership: N. F. HOWARD, R. W. HARNED

Committee on Codling Moth: W. S. HOUGH

Committee on Insecticide Terminology: ALFRED Weed, R. C. ROARK

Committee on Common Names of Insects: (two to be selected) E. H. STRICKLAND, F. E. GUYTON, P. D. SANDERS, CLAUDE WAKELAND, F. W. CRAIG

Committee on JOURNAL Publication: (two to be selected) W. E. DOVE, H. A. SCULLEN, B. A. PORTER, S. B. FRACKER

Committee on Popular Entomological Education: G. F. MACLEOD and J. A. HYSLOP

Committee on Relation of Entomology to Conservation: JAMES A. BEAL and S. A. GRAHAM

Trustee on Crop Protection Institute: WILLIAM B. HERMS, F. L. CAMPBELL

Trustee for Permanent Fund: S. B. FRACKER, W. H. WHITE, C. J. DRAKE

Representative on Council of Biological Societies: W. H. ANDERSON, R. W. HARNED, C. P. CLAUSEN

Counselor for the American Association for the Advancement of Science: F. C. BISHOPP

Joint Committee on Insect Collections: C. F. W. MUESEBECK

Joint Committee for the Promotion of Official Entomology: W. P. FLINT

Editorial Board, JOURNAL OF ECONOMIC ENTOMOLOGY:

Editor—L. M. PEAIRS
Honorary Editor—E. P. FELT
Associate Editor—H. B. WEISS
Business Manager—ERNEST N. CORY
WILLIAM MIDDLETON
E. L. CHAMBERS
Z. P. METCALF, *Chairman*

REPORT OF THE MEMBERSHIP COMMITTEE

During the past year there have been seven deaths of members of the Association, in addition to one that was not reported last year:

W. S. Abbott (October)
L. G. Baumhofer (June)
A. C. Davis (January)
R. W. Doane (December)
Charles T. Musson, New South Wales (June)
George A. Root (May)
J. L. Webb (January)
M. H. Swenk (July, 1941)

The Committee recommends the election of the following 125 persons to active membership in the Association:

Abramitis, Walter William, Hillside, N. J.
Abrams, Walter W., East Islip, N. Y.
Adams, Robert M., Cincinnati, Ohio
Alexander, Riley A., El Paso, Texas
Anderson, John W., Corpus Christi, Texas
Anderson, Roger F., Asheville, N. C.
Ashdown, Donald, Ithaca, N. Y.
Atkins, Edward Laurence, Jr., Urbana, Ill.
Bacon, Oscar G., Sanger, Calif.
Baker, Norval, Ames, Iowa
Bakke, Kenneth R., St. Louis, Mo.
Balankura, Blancherd, Baton Rouge, La.
Barnes, Martin M., Ithaca, N. Y.
Bartlett, Lawrence M., Ithaca, N. Y.
Bean, James Lyle, Augusta, Me.
Bishop, Roy K., Orange, Calif.
Blank, Walter, Poughkeepsie, N. Y.
Brandenburg, John F., Stuttgart, Ark.
Bunn, Lynn K., Madison, Wis.
Burnside, Carlton E., Laramie, Wyo.
Carisoza, James E., Bell, Calif.
Carncross, I. B., Syracuse, N. Y.
Casanges, Mrs. Abby H., Chevy Chase, Md.
Chada, Harvey L., Newark, Del.
Church, Luther M., Norfolk, Va.
Clapp, Alston, Houston, Texas
Cooper, J. Lamar, Ames, Iowa
Cross, H. F. Ringgold, La.
Currier, Donald L., San Jose, Calif.
Dambach, Charles A., Columbus, Ohio
DeSellem, Fred E., Olympia, Wash.
deSouza, Antonio Alexandre, Bahia, Brazil
Dutsch, Thomas P., Baton Rouge, La.
Eads, Richard B., Austin, Texas
Enke, Joseph William, Durham, N. H.
Enns, Wilbur R., Columbia, Mo.
Farr, Noel C., North East, Pa.
Farrell, William, Brooklyn, N. Y.
Feuerstein, Alexander, Long Island City, N. Y.
Fowler, Jack R., Logan, Utah
Gauthier, Georges, Quebec, Canada
Gerberg, Eugene J., Atlanta, Ga.
Gerberich, John B., Columbus, Ohio
Gibson, Walter S., Lafayette, Ind.
Girth, Harold B., Trenton, N. J.
Goble, G. J., Baton Rouge, La.
Gosnell, Homer R., Philadelphia, Pa.
Griffiths, James T., Jr., Auburn, Ala.
Gross, Joseph, Cleveland, Ohio
Hamstead, Elwood O., Kearneysville, W. Va.
Harrington, Cecil Davis, Milpitas, Calif.
Hatch, M. B., Corvallis, Ore.
Henderson, Charles A., Chelan, Wash.
Hess, Jacques J., New York, N. Y.
Hill, Clarence Howell, Yadkinville, N. C.
Hitt, Clifton B., Kalamazoo, Mich.
Hoidale, Paul, Harlingen, Texas
Horsfall, James G., New Haven, Conn.
Howard, Louis B., Albany, Calif.
Hynak, Joseph R., Scranton, Pa.
Irvine, Milton B., Alhambra, Calif.
Ives, Harlem B., Detroit, Mich.
Kartman, Leo, Los Angeles, Calif.
Kelly, Lewis B., Madison, Wis.
Kenaga, Eugene Ellis, Midland, Mich.
Klein, Harvey W., Milwaukee, Wis.
Koblitsky, Louis, Philadelphia, Pa.
Kostal, Emile, Hoboken, N. J.
Kotler, Louis, Memphis, Tenn.
Kramer, Marvin C., Nogales, Ariz.
Kurtis, Stephen, Ann Arbor, Mich.
Laing, Miss Barbara A., Cleveland, Ohio
Lee, Cecil S., Ithaca, N. Y.

Lemon, Robert, Burlington, Vt.
Levenson, Mathias F., Omaha, Neb.
Lewis, Bert, Muncie, Ind.
Lieux, Davidson B., Fort Ord., Calif.
McKelvey, John J., Jr., Ithaca, N. Y.
McLeroy, C. D., Alvarado, Texas
Maddock, Darrell R., Ogden, Utah
Marvin, Philip H., Moorestown, N. J.
Maxwell, J. Myron, Raleigh, N. C.
Menard, Charles J., San Francisco, Calif.
Miner, Floyd D., Fayetteville, Ark.
Mohr, Carl O., Urbana, Ill.
Morris, K. P., Tarrant, Ala.
Muma, Martin H., College Park, Md.
Nelson, Howard D., Whittier, Calif.
Owen, William B., Laramie, Wyo.
Parencia, C. R., Brownsville, Texas
Patel, Gunvantlal Amritlal, Ithaca, N. Y.
Peterson, Allan G., Jackson, Miss.
Portman, Roland W., Columbia, Mo.
Potter, O. L. Ecorse, Mich.
Pratt, John J., Jr., Ithaca, N. Y.
Prescott, Hubert W., Spokane, Wash.
Raley, Thomas C., St. Louis, Mo.
Ramsey, M. J., Walden, N. Y.
Ransford, J. A., San Francisco, Calif.
Renfroe, Clyde E., Chicago, Ill.
Rich, H. R., Chicago, Ill.
Roberts, Reed Stewart, Logan, Utah
Ruffin, W. A., Auburn, Ala.
Ruwaldt, W. A., Corpus Christi, Texas
Schwab, O. H., Watsonville, Calif.
Scott, Louis M., Seattle, Wash.
Skinner, Frank E., West Lafayette, Ind.
Smith, Jules B., Chicago, Ill.
Spishakoff, Leonard M., Chelan, Wash.
Standen, Anthony, Annapolis, Md.
Straube, Harold Louis, Bloomfield, N. J.
Taschenberg, Emil Frederick, Geneva, N. Y.
Telford, Horace S., Fargo, N. D.
Teubeville, L. E., San Antonio, Texas
Tsuyuki, Geary M., Camp Robinson, Ark.
Vogal, Lothar, Brooklyn, N. Y.
Walter, Robert Lewis, Knoxville, Tenn.
Walton, R. R., Ada, Okla.
Wheeler, Ellsworth H., Geneva, N. Y.
Whitcomb, Willard Hall, Ithaca, N. Y.
Williams, Ada, Albuquerque, N. M.
Wilson, Clifton A., Little Rock, Ark.
Wilson, Frank E., Walnut Creek, Calif.
Young, T. Roy, Jr., Tampa, Fla.
Youngman, Henry Emil, Corpus Christi, Texas

Twenty-six resignations have been received and accepted, and eight members have been reinstated.

The Committee recommends that members on military leave for the duration be exempt from the payment of annual dues.

GEORGES MAHEUX — S. W. BILSING
RALPH H. SMITH — ALBERT HARTZELL
E. P. BREAKEY — *Chairman*

REPORT OF THE JOINT COMMITTEE ON MILITARY ENTOMOLOGY OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS AND ENTOMOLOGICAL SOCIETY OF AMERICA

President Weiss, of the AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, and President Alexander, of the ENTOMOLOGICAL SOCIETY OF AMERICA, appointed a committee consisting of C. H. Richardson and F. L. Campbell to collaborate with P. N. Annand in initiating steps toward carrying out the intent of the following resolution adopted at the San Francisco meeting of the AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS:

"WHEREAS, during this National Emergency the profession of Entomology is conscious of the need for leadership and organization of effort, and

"WHEREAS, the Bureau of Entomology and Plant Quarantine is in a unique position to furnish this leadership, and

"WHEREAS, time is a vital element in the development of a national program, therefore,

"BE IT RESOLVED, that the Chief of the Bureau of Entomology and Plant Quarantine be requested to call together at the earliest practicable moment a group of entomologists representative of the various entomological organizations, institutions, and geographic areas of the United States for the purpose of ascertaining the best possible use of entomological personnel and facilities and for the development of a program for the most effective utilization of these resources, and that a copy of this resolution be sent to the Secretary of Agriculture and the Chief of the Bureau of Entomology and Plant Quarantine."

The committee met and made its report to the Presidents of the two Associations on April 6, 1942. The committee reports made reference to its interpretation of the resolution and the field of its discussions as follows:

"The stated purpose of the resolution calls for a program for the most effective utilization during the war of both entomological personnel and facilities and therefore might be interpreted to include both military and civilian activities of entomologists. However, those who were present at the meeting of the Teaching Section in San Francisco where the resolution originated were of the opinion that its primary purpose was to facilitate the utilization of entomological personnel in the military services. Your committee therefore felt that it would be best to confine its discussions and recommendations to the military problem, as it seemed impossible to cover effectively the broader and unlimited field of civilian service."

It reviewed the possible relations of entomologists to the military, and nominated a committee to act for the two organizations—outlining its views as to the functions of this latter committee and suggesting that it be called "Committee on Military Entomology." It also proposed a questionnaire designed for use in assembling information on entomologists to aid the Army and Navy in securing properly trained personnel for entomological work and to provide data on entomologists for any specialized service that might arise in connection with the war.

Upon its appointment, the Committee on Military Entomology began to function at once by further developing contacts previously made with responsible officers in the Medical Departments of the Army and Navy where entomologists were urgently needed. Steps were also taken to prepare, print and distribute to the membership of the AAEE and ESA, through the secretaries of these societies, a questionnaire which was first presented to the military for comment. The distribution of the questionnaire was not restricted to the membership, however, since the committee's aim is to be of the greatest possible service to entomologists as a whole and especially to the military services.

Questionnaires, totaling 1,025, have been completed and returned. These have been classified according to expressed interest in entering the military service, and training and experience. They have been carded and records are maintained as far as practicable on those entomologists who have entered the military service.

The Committee on Military Entomology has maintained close contact with the personnel officers of the Army and Navy, and has supplied them, when requested to do so, with lists of entomologists available for service. The complete information as it appears on the questionnaire, together with the information regarding these men as supplied in letters of recommendation, has furnished the basis for most appointments.

The Army has commissioned more than 100 men in the Sanitary Corps for entomological work. Some additional men will soon be commissioned and it is probable that this number will be materially increased during the year.

A few of the entomologists in the Army were reserve officers who were called to active duty and transferred to the Sanitary Corps but most of them were commissioned as First Lieutenants. Four entomologists now rank as Lieut. Colonels, eight as Majors, and 14 as Captains.

The Hospital Corps Volunteer Service (H-V-(S)) of the Navy has commissioned a considerable number (figure cannot be divulged) of entomologists and some additional ones may be appointed during the year.

The entomologists entering the Navy were commissioned as Ensigns and Junior and Senior Lieutenants.

The Committee has been able to lend some assistance to the U. S. Public Health Service in finding entomological personnel for mosquito and other insect control work in extra-cantonment areas.

Consideration was given to the possibility of more fully utilizing the training and experience of entomologists volunteering or being inducted into the service, by having them detailed to entomological or other biological work. Accordingly arrangements were made to have entomologists included in the enrollment of medical technologists by the American Red Cross. Through this plan a number of entomologists have been assigned to the Medical Department where they will be available for detail to entomological work.

The opportunities for entomologists to perform useful service in branches of the Army other than the Medical Department have also been explored, and the attention of the Corps of Engineers and Quartermaster Corps has been directed to the ways in which entomologists might be advantageously used in those branches of the service. These Corps have made some use of entomologists of the Sanitary Corps and there is reason to believe that some men may be commissioned for full-time service in them.

The type of training best fitting men for entomological work in the armed forces has been considered and advice on curricula has been supplied to a number of universities. Naturally, under present conditions many difficulties are encountered in training entomologists but these are probably no greater than those confronted in other fields. The lack of training in medical entomology has been forcefully brought out in connection with our efforts to assist the military in finding men ready to handle work in this field. Although men well trained in agricultural entomology have given satisfactory service with the armed forces, there is no doubt that their initial effectiveness would have been enhanced if all received training in medical entomology as an essential part of their curriculum.

A rather extensive correspondence has resulted from inquiries as to opportunities and needs for entomologists in the military service. In this and in personal contacts of the committeemen an effort has been made to help entomologists evaluate their opportunities for service to our Nation, whether in the armed forces or in their present capacity as civilian entomologists.

Although the drain of the military demands for entomologists has been severely felt in some quarters thus far it is thought that the needs have been reasonably well met and the number of entomologists has been sufficient to fill available positions.

The provision of special training courses for commissioned entomologists has been discussed with Army and Navy officials, but in general they have felt that provision of formal courses in medical entomology and supporting subjects is difficult to arrange and the needs of the service can be met by less formal training as now provided by the Army and Navy.

Return of troops infected with malaria, filaria, or other insect borne diseases presents a menace to the civilian population. This should be provided for by starting now to develop post-war plans for the full utilization of trained sanitary entomologists and others (such as engineers, mappers, supervisors of labor, and developers of machinery for antimosquito work) mustered out of the service. This would absorb trained and experienced personnel, and help to protect the health of our people; thereby maintaining the productive capacity of the civilian population.

Efforts to impress military leaders with the importance of maintaining in the military services, after the war, an adequate number of entomologists should be considered a function of this Committee. The protection of personnel, supplies, and installations from the insect menace is a necessary continuing function of the armed forces that can be handled best by those now gaining experience under war conditions. Such men will be able to furnish the leadership quickly and effectively to implement entomological work in any subsequent emergency.

In order that the committee may be of the greatest service to military authorities and entomologists, it is urged that information be sent to the Committee promptly regarding entomologists entering the military service either by being commissioned, inducted, or volunteering. This information should include date of entrance into the service and branch of the Army and Navy to which assigned.

In order that the Committee may be of maximum service to military authorities and entomologists, it is essential that a record of the military allocations of every entomologist be available to the Committee. More than 500 such records are now available through the list that has been compiled in the office of Secretary Cory. Completion of this list is urgent and the Committee requests that those who have not sent in to Secretary Cory a record of their present military service do so at once. Those who have not sent in the War Work Questionnaire should send this immediately to Dr. F. C. Bishopp.—2-10-43.

E. N. CORY
ROBERT MATHESON
F. C. BISHOPP
Chairman

STATEMENT OF RETIRING PRESIDENT (1942)

During 1942 eleven special committees were appointed as follows, seven of them having been authorized by the Association at the San Francisco meeting in December, 1941.

COMMITTEE ON THE INSECTICIDE SUPPLY SITUATION.—J. L. Horsfall, *Chairman*, C. C. Hamilton, R. C. Roark. Authorized in Report of Resolutions Committee, for the purpose of gathering and disseminating information on the supply of insecticides. Reports of this Committee will be found in the April (1942) and December (1942) issues of the JOURNAL. In addition this Committee has distributed mimeographed reports by mail.

COMMITTEE ON MODEL INSECTICIDE AND PEST CONTROL LAW.—W. P. Flint, *Chairman*, J. J. Davis, H. F. Dietz, C. N. Dold, N. S. Prescott, D. B. Mackie. Authorized in Report of Resolutions Committee, to look into the desirability of preparing a model law on insecticides and pest control.

INTERNATIONAL COMMITTEE ON GRASSHOPPER RESEARCH.—H. C. Severin, *Chairman*, J. R. Parker, G. A. Dean, R. D. Bird, F. A. Fenton, K. M. King. Authorized by Executive Committee, to operate on lines similar to those of the standing Codling Moth Committee.

COMMITTEE ON ESTIMATING INSECT DAMAGE AND POPULATIONS.—J. A. Hyslop, *Chairman*, J. R. Parker, M. F. Wadley, W. P. Flint, Clay Lyle. Authorized in Report of Resolutions Committee for the purpose of formulating standard procedures in connection with estimates of insect damage, and populations.

COMMITTEE TO STUDY ALL PHASES OF THE PUBLICATION OF *Entoma*.—F. L. Campbell, *Chairman*, C. C. Hamilton, Clay Lyle, J. S. Houser, Alfred M. Boyce, Neely Turner, Roy E. Campbell. Authorized by Executive Committee in order to determine if *Entoma* should be a Branch or an Association publication, and to study the conflicting views of the Eastern and Pacific Slope Branches. The report of this Committee was made to the Eastern Branch, in New York, on November 19, 1942 and this Branch voted that it be received with favorable consideration.

COMMITTEE TO CONSIDER THE RECOMMENDATIONS IN THE REPORT OF THE COMMITTEE APPOINTED AT PHILADELPHIA BY THE SECTION OF PLANT QUARANTINE AND INSPECTION, PARTICULARLY WITH RESPECT TO THE NAME OF THE SECTION, TYPE OF PROGRAMS AND RELATION OF SECTIONS TO THE MAIN ASSOCIATION.—B. A. Porter, *Chairman*, Z. P. Metcalf, T. H. Frison, A. M. Boyce. Authorized by Executive Committee, for the purpose indicated in the title.

PRELIMINARY COMMITTEE FOR THE PURPOSE OF ASCERTAINING THE BEST POSSIBLE USE OF ENTOMOLOGICAL PERSONNEL AND FACILITIES IN CONNECTION WITH THE WAR EFFORT.—F. L. Campbell, C. H. Richardson.

At the San Francisco meetings there was adopted a Special Joint Resolution of the *Entomological Society of America* and the *American Association of Economic Entomologists*, asking the Chief of the Bureau of Entomology and Plant Quarantine to call entomologists together for the purpose of formulating policies relative to the war. Acting upon this the Chief of the Bureau was confronted with replies indicating that a representative attendance could not be expected. He then asked both societies to appoint committees to confer with him. As a result of this conference the above committee made recommendations which led to the appointment of a Joint Committee on Military Entomology.

JOINT COMMITTEE ON MILITARY ENTOMOLOGY.—F. C. Bishopp, *Chairman*, E. N. Cory, Robert Matheson. This committee has been concerned with registering entomologists for military service, bringing about a recognition of entomological problems by military officials and with other problems of entomology and the war.

COMMITTEE ON THE COORDINATION OF ENTOMOLOGY WITH THE WAR EFFORT.—E. F. Phillips, *Chairman*, F. N. Wallace, P. D. Sanders, L. M. Peairs, J. S. Houser, A. S. Hoyt, E. N. Cory, S. A. Graham.

Because the entire emergency effort of the *Association* was not being fully met by the activities of the two other "war" committees, the above committee was appointed for the purpose of formulating a policy and plans for controlling insects that threaten the goals set by the Government for the increased production of certain crops, and for the purpose of making recommendations involving other phases of the effect of the war upon entomology and entomologists. Its reports have appeared in the issues of the JOURNAL for April and June, 1942.

LOCAL COMMITTEE.—J. L. Horsfall, *Chairman*, C. H. Curran, A. B. Klots, H. T. Spieth, Max Kisliuk, E. P. Felt. This joint committee representing both national entomological organizations had its plans terminated by the cancellation of the annual meeting.

NOMINATING COMMITTEE.—Z. P. Metcalf, *Chairman*, E. L. Chambers, William Middleton.

Although the cancellation of the annual meeting made impossible all personal discussions and exchanges of opinion, which are especially desirable in furthering the war aims of the country and of the *Association*, the final reports of the committees will be published in the JOURNAL for the consideration of the members.

I wish to thank the members of all the foregoing committees for their efforts in behalf of the *Association* during the past year and to express my grateful appreciation to all members for their support.

HARRY B. WEISS

REPORT OF SPECIAL COMMITTEE ON *ENTOMA*

In the Spring of 1942 this committee was appointed by President Harry B. Weiss to study the conflicting views of the EASTERN BRANCH and the PACIFIC SLOPE BRANCH on future publication of *Entoma* and to make recommendations for consideration by the EASTERN BRANCH and the parent ASSOCIATION at their respective annual meeting in 1942.

Briefly, the PACIFIC SLOPE BRANCH contends that western listings in *Entoma* are incomplete and therefore it is not satisfactory for use on the West Coast. This BRANCH feels that the listing can best be completed by publishing *Entoma* under the auspices of the parent ASSOCIATION, with an editorial committee representing all parts of the country and that it would be desirable to strengthen the parent ASSOCIATION in this way.

The EASTERN BRANCH points out that *Entoma* is a successful and profitable enterprise initiated by the BRANCH as a source of revenue to meet expenses peculiar to the BRANCH, that the BRANCH cannot operate in its accustomed manner without *Entoma*,

and that the objection of the PACIFIC SLOPE BRANCH to inadequate listings can be easily overcome by cooperation between the two branches.

The PACIFIC SLOPE BRANCH is not eager to spend time and effort in making money for the EASTERN BRANCH, but would do so for the parent ASSOCIATION. Without opportunity to work for *Entoma* through the parent ASSOCIATION, the PACIFIC SLOPE BRANCH would seriously consider issuing its own Directory for the West Coast.

In order to study the foregoing problem, the Committee was provided with detailed factual briefs furnished by the secretaries of the two branches and with a general discussion of the problem written by the Chairman. The following recommendations are based on thoughtful consideration of this material.

(1) Publication of *Entoma* by the EASTERN BRANCH should be continued during the war, because—
   a. Change in personnel of the Editorial Committee might upset plans now being made for the next edition of *Entoma*.
   b. The Executive Committee, busy with war duties, probably cannot now take time to work out a plan for properly compensating the EASTERN BRANCH for loss of *Entoma*.
   c. The insecticide industry of the West Coast is now organized and cooperating as never before and should be able to provide listings and advertising for *Entoma* through the Agricultural Insecticide and Fungicide Association and the Pacific Insecticide Institute, with little effort on the part of West Coast Entomologists.
   d. Time is needed to acquaint all entomologists with the problem.

(2) *Entoma* should be transferred to the parent ASSOCIATION after the end of the war, provided—
   a. The EASTERN BRANCH recognizes the desirability of placing national entomological undertakings in the hands of the parent ASSOCIATION, and will voluntarily offer *Entoma* to the parent ASSOCIATION.
   b. The PACIFIC SLOPE BRANCH does not start a Western Directory.
   c. The Executive Committee of the A.A.E.E. does not forget its present and continuing responsibility to work out an acceptable plan, not only for compensating the EASTERN BRANCH for loss of *Entoma*, but for placing all branches on an equitable basis with respect to publication in the JOURNAL OF ECONOMIC ENTOMOLOGY and other financial relations with the parent ASSOCIATION.

(3) All branches should pull together to build the strongest possible national ASSOCIATION for the benefit of all entomologists and their service to the Nation, patiently striving to overcome existing differences.

A. N. BOYCE — CLAY LYLE
R. E. CAMPBELL — NEELY TURNER
C. C. HAMILTON — F. L. CAMPBELL
J. S. HOUSER — *Chairman*

REPORT FOR 1942 OF THE COMMITTEE ON COOPERATION WITH THE PEST CONTROL OPERATORS

The reports of the Committee on Cooperation with the Pest Control Operators of previous years, almost without exception, have emphasized the need for legislation to regulate the practice of pest control. The thought is brought out that in the absence of a State law of such a character the pest control operators are subject to local ordinances and requirements which vary greatly as between cities and local subdivisions. It has been pointed out that this exposes the industry to a great variety, if not a confusion, of more or less local requirements. Consequently, it is not surprising that committee recommendations in former years have most frequently included one as to the desirability of drafting a "model" law on this subject.

Early in 1942 a special committee was appointed to look into the drafting of a pest control law. The Committee on Cooperation with the Pest Control Operators took the point of view that by this action it was not under obligation to draft such a law. It thereupon considered various other avenues in which it might be helpful. Thought was given to the possibility of explorations that might be made to determine the availability of insecticides commonly used by the pest control industry and whether there might be need for substitutes. The situation with respect to insecticides used by the industry proved to be less acute under war conditions than was first expected, however, and it early developed that existing agencies of the government had the insecticide problem thoroughly in mind.

The suggestion was made to the standing Committee that it contact the pest control industry and assemble their comments, particularly criticisms directed at the entomologists; also that the Committee get the comments of the entomologists with respect to the pest control operators. After some consideration and for a number of reasons this proposal was not followed up.

Meantime the chairman of the Committee on Cooperation with the Pest Control Operators was appointed ex officio a member of the special committee previously mentioned. That Committee had not begun to function nor, so far as the knowledge of this Committee goes, has it begun up to this time. The Resolution passed by the Association at San Francisco instructed this special committee "to look into the desirability of preparing a model insecticide and pest control law and if they think it advisable prepare such a law or laws with a statement of the general principles underlying such proposals and report to the next annual meeting." The Committee on Cooperation with the Pest Control Operators is mindful that it has final responsibility within the Association for drafting a pest control law. It does not consider an insecticide law within its field. Furthermore, this Committee believes that one law combining the features of an insecticide law and a pest control law would limit the usefulness of each feature. Responsive as the Committee is to what it considers a mandate from the Association it desires to call attention to its objections to the use of the word "model" as employed in the resolution. "Model" laws are all too few, even those that have been many times revamped. This Committee subscribes to the belief that laws are usually the result of a process of evolution and that only by making a start can we hope to achieve a law that will be reasonably satisfactory in meeting the situations that may be expected in the various States.

The Committee is fully conscious that before undertaking to draft such a law, it is desirable to have the points of view of many entomologists, pest control operators, and others interested in various sections of the country; consequently for the purpose of

pointing criticisms and developing suggestions, the committee is including in this report certain features which, it believes, should be included in such a law. This is considered as a preliminary step and comments and criticisms during the next few months will be appreciated. At the next occasion to submit an annual report, the committee plans to submit a draft of a law.

Suggested Title for the Law: AN ACT To Regulate the Practice of Structural Pest Control; Creating a Structural Pest Control Board; and Granting to Said Board the Power to Make Rules and Regulations Governing the Qualifications and the Practicing of Persons Engaged in Professional Services in Structural Pest Control; to Prevent Fraudulent Practices in the Said Professional Work and Provide Penalties for the Violation of This Act and the Rules and Regulations Made by the Board under Authority of This Act.

This Act should be administered and enforced by a board to be appointed by the governor which should be known as the "Structural Pest Control Board." It should be composed, ex officio, of the highest ranking member or employee of the Department or Board of Health having a degree of Doctor of Medicine and licensed under the laws of the State to practice medicine; a qualified entomologist who is also an official and employee of the State; and the State Engineer. In addition, there should be one or two pest control operators, depending on whether a board of four or five is desired. The committee would appreciate suggestions as to the term of office. It is inclined to favor an indefinite term by including the language that membership on this Board is "at the pleasure of the governor." The committee feels that the entomologist should be the executive member of the Board.

The committee defines "structural pest control" or "pest control" as "receiving fees for the identification of the causal agent of infestations or infections, the making of inspections, or the use of insecticides, fumigants, or allied chemicals, or alterations in the structure itself for the purpose of eliminating, exterminating or preventing infestation of ants, bedbugs, carpet beetles, woodboring insects, cockroaches, fleas, moths, mice, rats, silverfish, spiders, termites, infection of fungi, and other such pests which may invade household and other structures, or the submission of bids for any of such work."

It also defines "household" as "any structure and its contents which are used for man and his convenience."

"Structural pest control operator" is defined as "any person licensed by the Board to practice structural pest control who does so for hire as a business."

The law should prohibit the practice of structural pest control except by licensed operators. Any person should be permitted to apply for a license. The committee would appreciate comments as to whether or not fees should be required.

The committee believes that any person who has done pest control work for a year, equivalent to the work this law seeks to insure, should be granted a license without examination upon application, including payment of fees, if required.

The qualifications of other applicants should be ascertained by written or written and oral examinations. The Board should definitely inform itself that an applicant for a license as operator is qualified in the use and understanding of the English language, including reading and writing; the building, safety, and public health laws of the State and any of its political subdivisions, or that part of the same relating to any act of acts connected with the practice of the work of structural pest control; the labor laws of the State; poisons and other chemicals used in structural pest control; the theory and practice of structural pest control; the provisions of the Act. The law should require applicants to furnish evidence of good character.

Licenses should be renewed annually.

The Act should prescribe and empower the Board to promulgate a statement of the acts or omissions constituting grounds for disciplinary action. It should authorize the Board to investigate the action of any licensee or applicant for license, but before determining the guilt of a licensee, the Board should be required to hold a hearing, conducted with due regard to the rights of the accused, and any disciplinary action taken by the Board should be subject to review by the courts of the State. Revocation of the license should be recognized as a form of disciplinary action and provision should also be made for the restoration of a license under prescribed circumstances.

The Act should prescribe or authorize the Board to take steps to protect the public from the misuse of a license such as might occur through operations carried on by a partnership or corporation with which was connected a person to whom a pest control operator's license had been issued.

The Committee's suggestions for inclusion in a law to regulate the practice of pest control have not yet been reviewed by the representatives of the pest control industry. This is considered to be the first step in the preparation of such a law. As stated previously, the committee invites criticisms and suggestions. It is particularly anxious to hear from pest control operators and other entomologists. As previously stated, the committee plans to draft a law to be reported to the Association at the time the annual reports for the calendar year 1943 are submitted.

ROGER B. FRIEND
AVERY S. HOYT, *Chairman*

REPORT OF THE REPRESENTATIVE OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS ON THE DIVISION OF BIOLOGY AND AGRICULTURE OF THE NATIONAL RESEARCH COUNCIL, 1942

The Annual Meeting of the Division of Biology and Agriculture of the National Research Council was held in Washington, D. C., April 11, 1942. The minutes for the Annual Meeting held April 12, 1941 were read and approved. Reports of various committees of the Division were made. It was announced that a special committee dealing with war problems concerning the Division had been appointed. Dr. Robert F. Griggs, Division Chairman, presided.

Of interest to entomologists were discussions pertaining to entomology and the war. Dr. E. O. Essig, representing the Entomological Society of America, and your representative called attention to the role that entomology was playing and should play in the war effort. At the time of this meeting no organized program representing the views of our two societies had been presented. Speaking as individuals inter-

ested in the work that our profession was doing, we suggested to the War Committee of the Division of Biology and Agriculture that entomology was serving the war effort in the following ways: (1) protection of plant and animal food crops from insect damage, (2) protection of foods, fabrics and fibers that had already been produced from destruction by insects, (3) protection of man and domestic animals from insect vectors of disease as well as from insects that are of annoyance, (4) protection of sanitary conditions involving pest control around military barracks and civilian establishments, (5) protection of national welfare through quarantine and inspection services which are becoming increasingly difficult to perform. It was suggested that the Council should contact Selective Service Headquarters in an attempt to get recognition for essential workers in entomology and determine if their deferment could be obtained. The question of training entomologists for a place in the war effort as well as for the future was discussed. It was felt that a large number of entomologists would be needed and consideration should be given to provide them with adequate training. Additional topics on this general subject were discussed.

The Division of Biology and Agriculture had no committee dealing with problems of crop protection or with entomology and plant pathology in a broad sense. It was realized that more than ever, the two sciences would need to work together for the prevention of crop losses. The representatives of the societies concerned felt that the National Research Council should have a committee during this period of war that could deal with problems as important as the ones arising in insect and disease control. If for no other reason, it was felt that the Council should be kept informed on the activities of state and federal agencies as well as industry in this field and be in a position to lend its support to any program that might need it.

The Division of Biology and Agriculture voted to establish a committee on Crop Protection. Dr. Griggs invited the entomologists and plant pathologists of the Division to suggest a membership for the committee and certain broad objectives. These suggestions were made at the adjournment of the meeting. There was a delay of several months in appointing the committee and in the meantime other committees of entomologists from our Association were active on problems pertaining to entomology and the war. The Committee on Crop Protection, headed by Dr. E. C. Stakeman of the University of Minnesota, met in Washington October 12, 1942. This new committee included members of war committees of the phytopathologists and entomologists. After discussion of problems and objectives, the committee felt itself charged primarily with the responsibility of bringing about as close coordination of effort as possible between entomologists and plant patholo gists, with a view of safeguarding economic plants. This can be attained through existing agencies, particularly the war emergency committees of the American Phytopathological Society and the American Association of Economic Entomologists and the Entomological Society of America. Additional objectives included:

1. Attempts to encourage the accumulation of more extensive and precise data regarding losses caused by crop pests and crop diseases, together with more adequate plant pest and plant disease surveys.
2. Educational activities designed to increase the understanding of the people in general to the menace of plant diseases and insect pests.
3. To promote the summarizing of important information for the use of extension men and investigators.
4. To promote closer cooperation between entomologists and plant pathologists on a regional and on a project basis.
5. To encourage closer cooperation between plant pathologists and entomologists in breeding varieties of crop plants for combined resistance to insect pests and plant diseases.
6. To encourage important plant disease eradication programs and insect suppression programs.
7. To attempt to encourage basic research in those fields and on those problems where interruption would result in disservice.
8. To help arrange for the best possible service with respect to fungicides and insecticides.

Respectfully submitted,
CHARLES E PALM

REPORT OF THE CROP PROTECTION INSTITUTE

Throughout the year 1942 the work of the Institute has been closely related to the war emergency. This has come about naturally and without radical change in the nature of the Insttitue projects. Much the greater part of the Institute's research program is directed toward development of new and better insecticides and fungicides, or toward utilization of by-product chemicals, or toward other objectives leading toward the successful growing of crops.

Inevitably the war has brought about shortages of various compounds customarily used. Some of these compounds are becoming critically scarce. Others are headed in that direction. Meanwhile, the demand for effective food production has increased. Under these circumstances emphasis is automatically placed on studies of compounds that might take the place of materials that are scarce, or may become scarce. There is no shift in fundamental Institute program, but rather in emphasis and point of view. Adjustment has come about promptly and automatically.

Because of these conditions the Institute enjoys an outstanding opportunity to contribute to the war effort. By intensifying its investigations, and by shaping them toward obvious needs, it can help to develop materials that will meet those needs. In this program the Institute is attaining considerable success.

In the shortage of technical men the Institute has had problems of manpower to meet. For example, in attempting to fill a vacancy in one of our substantial projects we have had repeatedly to search the country over for possible candidates. When a man was located and interviewed he turned out presently to be unobtainable, because of other demands for his services. This has consumed time and has cost money, spent in order to talk with a candidate who thought he would be available but turned out not to be. Similar difficulties may be expected for the duration.

It is gratifying to note that companies supporting work with the Institute are not inclined to hurry into the market with a new chemical without adequate data. Companies realize the opportunity, but in our experience remain surprisingly conservative in

drawing conclusions about the merits of a new material. We do not seem to be in danger of fathering new treatments that are inadequately backed by trustworthy evidence.

Dr. S. E. A. McCallan has served this year as assistant to the chairman and has contributed substantially to the Institute's progress.

Investigational Projects in 1942

(1) *Albi Chemical Company.*

This company manufacturers a copper compound extensively used in mildew-proofing fabrics for the armed forces. Through the cooperation of Dr. McCallan this compound was given preliminary test as a possible fungicide. Results were encouraging, provided safety to plants could be achieved. Further work in that direction is now in hand.

(2) *Armour and Company.*

We have continued an investigation of dried blood albumin as an adjunct for sprays, and as an emulsifying agent for oil sprays. Work is now under way at the New Hampshire experiment station. Part time help is employed. It has been found that dried blood at 1 lb. to 100 gallons enhances the effectiveness of nicotine sprays. Dried blood in combination with fuller's earth increases the adhesiveness of insoluble materials in suspension, such as sulphur, resulting in better deposit on foliage.

(3) *Carbide and Carbon Chemicals Corporation.—Fungicide Investigations.*

Under the supervision of Dr. McCallan this project has made substantial advance. Working in close cooperation with the research department of the supporting company our investigation has disclosed new and promising groups of compounds. Also, it has disclosed some fundamental facts about the relation of chemical structure to fungicidal activity. Three new compounds were applied to apple trees, through the cooperation of Dr. H. W. Thurston. Two of these gave outstanding results, both as regards control of apple scab and with respect to finish of fruit. Excellent progress has been made under Dr. McCallan in laboratory and greenhouse techniques. Dr. R. H. Wellman is employed full time on this project, with additional part time assistants.

(4) *Carbide and Carbon Chemicals Corporation.—Insecticide Investigations.*

These studies are conducted at the Pennsylvania experiment station, under the supervision of Dr. E. H. Dusham. Significant advance has been made in development of toxicants. Promising data have been secured, also, on repellents. Dr. E. N. Woodbury is employed full time, with part time assistants.

(5) *Floridin Company.*

This company mines fullers earth and manufactures products based on fullers earth. It has developed a process for combining fullers earth with other materials such as sulphur or Paris green. Investigations last year indicated an increased potency in a sulphur composite made by this method. Similar composites have now been made with Paris green, lead arsenate, calcium arsenate, arsenious oxide, and other materials. Those which have fungicidal relationships are being explored by Dr. McCallan, while those embodying insecticides are being investigated at the New Hampshire station. Results to date with several materials indicate that a new way has been discovered for building certain insecticides and fungicides. Part time help is being employed to date.

(6) *General Chemical Company, Inc.*

Investigations in various places were continued. In North Carolina applications of fungicides were made under the direction of Dr. Luther Shaw. A part time man was employed through the year. In Mississippi field plots of cotton were maintained through cooperation with R. L. McGarr. In Colorado field plots of potatoes gave excellent results with a new treatment for the tomato psyllid. This work was under the direction of Prof. George M. List. In Ohio, with the cooperation of Dr. F. L. Campbell, laboratory studies of modified arsenicals were carried out. At Boyce Thompson Institute, under the direction of Dr. McCallan, some new organics were tested as fungicides.

(7) *The Mathieson Alkali Works, Inc.*

Investigations of new amines and their residues were continued. The free amines were studied at the New Hampshire experiment station with special reference to their utilization in household fly sprays. Residues were tested as fungicides at the Pennsylvania experiment station, in cooperation with Dr. Thurston. The research laboratory of the supporting company is contuning its investigation of these compounds and their improvement. They are of especial interest because they use non-critical materials.

(8) *Röhm & Haas Company.*

Work with cuprous oxide was developed to the point where it became advantageous to assign a man to field studies exclusively. Dr. J. W. Heuberger, who has been employed by the Institute in these investigations for the past five years, was taken over by the supporting company for this purpose. Meanwhile, investigation of new organics as fungicides was continued. Dr. A. E. Dimond, who had been employed on this phase of the project, resigned to accept a permanent position in Nebraska. The laboratory studies of organics were continued at the Connecticut (New Haven) station, utilizing the services of Miss Kathryn J. Cooke. Search is proceeding for a successor for Dr. Dimond. The project continues to be under the supervision of Dr. Horsfall.

(9) *The Solvay Process Company.*

Preliminary work has been carried out with a new detergent manufactured by this company. Tests of possible fungicidal activity were made at Boyce Thompson Institute. Insecticidal studies have been done at the New Hampshire station. Some leads have been uncovered.

(10) *U. S. Industrial Chemicals, Inc.*

This project was organized for the purpose of investigating the growth-promoting capabilities of an organic material derived from the processing of molasses. Accurate information is sought as to the performance of the new material and the relation of performance to known constituents, including possible activity of hormones. The New Jersey station was selected for the project. Dr. Firman E. Bear is supervisor of the work. Dr. Robert S. Snell has been engaged as full time research associate.

Respectfully submitted,
W. C. O'KANE, *Trustee*

REPORT OF SPECIAL COMMITTEE OF AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Report of Special Committee appointed to consider the recommendations in the report of the committee appointed at Philadelphia by the Section of Plant Quarantine and Inspection, particularly with respect to the name of the Section, type of programs, and relation of sections to the main Association.

This committee was appointed by President Weiss March 24, 1942 pursuant to the recommendation in the report of the Executive Committee to the San Francisco meetings, adopted at a business session of the Association, December 31, 1941. This report included the following:

"Recommended that a committee be appointed to consider the recommendations in the report of the committee appointed at Philadelphia, by the Section of Plant Quarantine and Inspection, particularly with respect to the name of the section, type of programs, and relation of sections to the main Association, and to report at the New York meeting in 1942." (JOUR. ECON. ENT. 35: 128, 1942.)

The committee appointed at Philadelphia found that its assignment had ramifications beyond the scope of the Section of Plant Quarantine and Inspection, and involving the affairs of the main Association. It therefore made two reports. The first report related primarily to the affairs of the Section of Plant Quarantine and Inspection. (JOUR. ECON. ENT. 35: 140–42.) The second report, addressed to the Executive Committee, discussed further the program problems that have arisen, and recommended that a special committee be appointed to consider these matters for the benefit of the Association as a whole. For the information of the reader, the major part of this second report is quoted below:

"In its consideration of particulars the Committee found that the answers to many questions carried us beyond the field of the Section and into the province of the main Association. The Committee believes it may be of interest and it hopes worth while to present its observations to the Executive Committee as follows:

(1) That the program committee of the main Association does not believe it has the power to refer to appropriate sections, papers on subjects which would fall into the sphere of existing sections.

(2) That a given paper may be submitted to the program committee of the main Association and this automatically entitles it to a place on the general program which may become thereby something of a 'catch all.'

(3) That the principal interest in such papers may be such that they might well, if authority existed to do so, be referred to a section where the subject matter would more properly place them.

(4) That the general sessions already are seriously crowded, which tends to curtail discussion and reduce the size of the audience.

(5) That each year there is at least one group of papers, the subject matter of which warrants their presentation to a particular group rather than to the general session.

(6) While the Committee believes this situation may be met in part by the formation of more sections it does not believe existing sections plus new sections that may be added will provide sufficient elasticity. The growth of the Association and the broad field involved in the development in the field of entomological work leads the Committee to believe that the complexity of the problem facing the Program Committee will expand still further. Hence the Committee believes the Program Committee might be authorized and directed to refer papers to existing sections where the subject matter warrants or to form and set up apart from the main sessions smaller sessions which might be known as sections pro tem to which group would be referred those papers that treat of the same or closely related subject matters. A presiding officer for such temporary sections could be named by the Program Committee or the President of the Association as may be determined.

(7) That provision should be made by amendment of the Constitution and By-Laws if necessary including the regulations covering publication to insure that papers thus transferred to group sessions including sections, sections pro tem or symposia, would have the same rights as to publication in the JOURNAL as would prevail were they kept on the program for the general sessions.

(8) Various individual members of the Association on learning of the study being made by this Committee have expressed opinions as to Association meetings such as

(a) That there should be more sections of the Association

(b) That the general meetings should not be more than one session, either morning or afternoon, daily; that the other session be left open for symposia or section or other group meetings and

(c) That general sessions should be limited to invitation papers only.

(9) This Committee believes such questions should be studied carefully by the Association. In connection with some of these proposals it desires to observe that it has kept in mind that facilities should be available to every member of the Association so that there would be no danger that a place on some program—section or symposia or section pro tem or general—would be denied him if he desired to present a paper dealing with a subject falling within the general scope of the Association; that restricting the general sessions as has been proposed must not be permitted to endanger what we consider to be every member's right; that if the general session should be restricted in accordance with these or other proposals care should be exercised to provide for the inclusion on some affiliated program for all papers on whatever entomological subjects that may be submitted.

"This Committee recognizes that its suggestions would, if put into effect, bring about rather profound changes in the time-honored procedures of the annual meetings of the Association. It is mindful, however, that the Association is growing rapidly and that procedures that were adequate a few years ago with membership not more than half that of the present are now outgrown or fast being outgrown. However, in order that we do not engage unnecessarily in experiments that may prove disappointing or confusing, the Committee recommends:

(1) That the President of the Association be au-

thorized and directed to appoint a Committee representing the Association to consider the questions presented in this report and such additional points as it may deem pertinent and to report to the Executive Committee at the annual meetings in 1942, and

(2) That temporary authorization be conferred on the officers of the Association and its Sections, including the Program Committee, to the end that transfer of papers from the general session to existing sections at least on a mutual consent basis be made in order that the Association may have an opportunity to observe the procedure and determine its benefits and faults prior to more permanent action such as amending the Constitution, etc."

The points which the committee was requested to consider will be taken up in order.

1. *Name of the Section of Plant Quarantine and Inspection.* It is our understanding that at the San Francisco meeting the Section of Plant Quarantine and Inspection adopted the proposed name and that the present Committee is espected to make recommendations to the Association whether this name shall be finally accepted. Objection has been made to the proposed new name on the ground that the words "and Pest Control" is so broad that it includes parts of other fields not within the scope of the Section of Plant Quarantine and Inspection, including those occupied by commercial fumigators and household pest control operators. A further change in title is therefore suggested for consideration by the Section: "Section of Plant Pest Control and Quarantine." This would place greater emphasis on pest control, which, after all, is the main objective of the work falling within the scope of the Section, and the inclusion of the word "Quarantine" would indicate the regulatory aspects of these activities.

2. *Type of Program.* The need for improvement in the type of program of the annual meetings has been recognized by many members, and was discussed by the former special committee. It has long been very evident that the general sessions, aside from those invloving symposia, presidential addresses, and other special events, have become "catch-all" programs for papers on various subjects of restricted interest. The profession has become so highly specialized that few individuals are inclined to listen to many papers not in their immediate field; instead, they spend their time in informal conferences in the lobbies and elsewhere. This does not mean that any of these papers are not valuable contributions, but merely that they are, at the time, of immediate interest to comparatively few entomologists. The present committee agrees with its predecessor that the general sessions should consist of papers of broad general interest. It therefore recommends that the Program Committee be instructed to try to develop general programs of this nature which should consist for the most part of invitation papers, but would include any papers originally planned for sectional programs, which in the judgment of the Program Committee are of sufficiently broad interest to warrant a transfer to the general session, as well as any voluntary papers which seem to the Program Committee to be suitable for general session.

The general sessions should be held at times when no other activities are planned, preferably in the morning. Ample time should be allowed for the presentation and discussion of these papers.

Under the plan proposed by the earlier committee, and endorsed by the present committee, the majority of the volunteered papers would be placed in sectional meetings, either in the existing sections, or in special sectional meetings organized by the Program Committee on a temporary basis. Two or more sections could run concurrently. This would result in some conflicts, but because of the restricted interest offered by many of the papers, this should not cause serious inconvenience to many in attendance at the meetings.

It is believed that full authority exists for a change to this type of program. When the Program Committee was first set up as a standing committee at Atlantic City in 1936, the report of the Executive Committee included the recommendation that: "There be established a standing committee on Program, consisting of three members . . . . The function of this committee shall be to arrange the special features of the program and to make general recommendations to the Executive Committee in regard to the program." (JOUR. ECON. ENT. 30: 232, 1937.)

A year ago at San Francisco the Executive Committee recommended: "That the Program Committee be authorized to adjust sectional and main programs to best advantage." (JOUR. ECON. ENT. 35: 128, 1942.)

Both of these recommendations were accepted by the Association.

It is realized that the proposed plan would place even greater responsibility and an added burden of work on the Program Committee. In addition to developing the traditional symposia, it would be necessary for the committee to consult or correspond with entomological leaders throughout the country as to work completed or nearing completion that would furnish suitable material for general programs, and to exercise sound judgment in the selection of papers. It would be necessary to plan the programs early in the year, in order to give the authors enough time to prepare well-rounded papers.

In order that the interest of the various sections may be fully considered in working out the proposed type of program, it is further recommended that the Program Committee be enlarged to include the Secretary or other official of each Section, who has authority to make arrangements as to the program. The three members representing the Association as a whole would continue to be elected, one each year for a term of three years.

This committee believes that the proposed plan would in no way interfere with the traditional right of all members to a place on the program, expressed in the most recent By-laws as follows: "Article I, Section 1. All members have equal privileges as to presentation of papers and discussion at the meeting." (JOUR. ECON. ENT. 31: 170–72, 1938.) As long as everyone who wishes to present a paper is given a place somewhere on the program the requirements of the By-laws would seem to be fully met.

3. *Relation of Sections to the Main Association.* It seems obvious that the relations between the main Association and its sections should be such as will promote the best interests of the organization as a whole. On the problem of program adjustment, the matter under immediate consideration, the Constitution and By-laws of the Association, the petitions which were presented for the establishment of the existing sections, the reports of committees which have considered these petitions, and the proceedings of the business sessions at which the present sections were authorized, give no indication of the manner in which sectional programs shall be arranged and or-

ganized, nor as to the relation between sectional and general programs. It has of course been the common practice for each section to provide its own program, this being arranged by the Secretary or Chairman. There seems to be nothing, however, in the Constitution and By-laws, nor in the conditions under which the sections were established, which, under the proposed plan, would prevent the Program Committee from transferring to sectional programs any papers believed to be more suitable for delivery in the sectional meeting involved, nor to prevent the Program Committee from transferring to general sessions any papers of broad interest originally planned for a sectional meeting. Naturally, such action should be taken only on the basis of serving the best interests of the greatest possible number of Association members likely to be present at the meeting, after full consideration of the possible effect on the sectional program.

Respectfully submitted

A. M. BOYCE Z. P. METCALF
T. H. FRISON B. A. PORTER, *Chairman*

REPORT OF THE COMMITTEE TO CONSIDER A MODEL INSECTICIDE LAW

The committee did not have the opportunity of meeting during the year, but carried on a considerable amount of work by means of correspondence. It was felt that because of the extremely unsettled conditions, it would not be possible to draw up any law at this time either governing the sale of insecticides and fungicides or suggesting legislation bearing on regulations for Pest Control Operators. However, members of the committee have worked actively in contacting and discussing the matter of legislation with Pest Control Operators.

The chairman has met with the special committee on legislation of the National Pest Control Association, and very definite progress has been made toward the formulation of a model law. It has been agreed that legislation regulating Pest Control Operators would be best in the form of state legislation. Regulations passed by municipalities often vary within a single state and make it very difficult for companies doing business in a number of cities to carry on their work.

The National Pest Control Association is in general agreement as to the type of law which would be most acceptable to their Association and which at the same time would give protection to the public. It is fully realized that while legislation will help in eliminating fraudulent and quack operators, it is no panacea, and that the National Pest Control Association is doing more in their campaign to clean up the industry than can be accomplished by enactment of any form of regulations.

Some progress has also been made in connection with the matter of drawing up regulations affecting distribution and sale of insecticides. No definite law has been formulated due to the unsettled condition in the industry and the impossibility of forecasting at this time what insecticides might be available for general use during the next two or three years. The attitude of both groups with whom the committee has been working has been most helpful. It is felt that definite progress has been made and that the committee should be continued.

J. J. DAVIS D. B. MACKIE
HARRY F. DIETZ H. K. STECKEL
W. P. FLINT, *Chairman*

REPORT OF COMMITTEE TO STUDY THE PROBLEM OF OBTAINING ACCURATE AND DEPENDABLE ESTIMATES OF LOSSES OCCASIONED BY INSECTS

Your committee first interpreted the resolutions drawn up at the last annual meeting to mean that it was to make an estimate immediately to meet the war effort.

After circularizing the State, station, and other entomologists it became evident that due to the pressure of other war work this would be impossible. Therefore, your committee is reporting progress.

We believe that investigations should be undertaken wherever possible on the direct relation between insect populations and crop losses.

As to estimating insect populations, the basic principles of sampling will apply. *Randomness* (giving every unit a chance to be represented); and *objectiveness* (freedom from personal bias); need to be defined. The former is the basis of validity of error estimates. A good sample is determined after deciding on and limiting the population to be sampled. It will consist of as many and as small units as practicable The more numerous and smaller the units, the better will be the sample of a given total amount of material. The limit to this subdivision is always a practical one, never a statistical one. Border effect and the added expense of getting many small units are frequent limiting factors. It is frequently found that a sample systematically distributed through the material, or at least partially restricted in randomness, is more accurate than a purely random sample, because more *representative*. This will be true whenever real differences exist between sections of the field of inquiry, which is a usual condition. Restriction of randomness is accomplished by subdividing the field of inquiry (along known lines of variation if possible) and taking some units at random in each subdivision, insuring representativeness.

With insect populations we have the complication that we deal with enumerations, typically of small numbers per unit. This carries with it both advantages and disadvantages. The data require more caution in treatment by standard statistical methods; but we do have, with population counts, an expected minimum value for variance. This is convenient in several respects. It enables us to get some limit to sampling yielding a string of zeros, and to make inferences as to the maximum population that could be missed altogether by a given sampling intensity. It also enables us at times to look at population figures, and state at once that they cannot be considered really different, because we would expect that much variation in repeated sampling from the same material.

Damage to crops may be of at least three kinds. First, the crop units attacked may be spoiled for human use without necessarily reducing crop size, as with the codling moth on apple, and the corn earworm on sweet corn. Second, the vitality of the plants may be affected, reducing the crop without necessarily direct attack on the part used; the chinch bug on corn or aphids on melons furnish examples. Third, with perennial plants the future life of the crop plant may be threatened without necessarily involving either of the other kinds of damage; as with the peach borer or the San Jose scale.

In the first case, the assessment of damage is a rather simple scoring problem; sampling presents a

problem similar to that of studying insect populations. Correlation of damage with insect population present is not difficult; the relation will likely be shown directly in the sampling results. In the second case, the problem is often difficult. It will require careful replicated experiments, with other sources of variation pretty well equalized to tell what a population means in terms of loss. Some examples of progress in this field were given in last year's Presidential Address. Many more are needed. It is a reflection on entomology that we have worked for many years on most of our important pests without being able to say very definitely the loss they may cause at a given population level. In the third case, estimates of loss must consider longtime costs and replacement values.

This does not consider losses due to attacks on stored products, on animals, and on human health. In some cases extension of the logic for crops may serve for these problems; in others, values are involved that are hard to state in financial terms.

To promote this work your committee suggests that when this work is to be undertaken after the war a number of agencies be contacted with the thought of conferring and taking an active part in appraising annual losses caused by insects. Among these might be mentioned: the United States Department of Agriculture Office of Experiment Stations, United States Department of Agriculture Extension Service, United States Department of Agriculture Bureau of Entomology and Plant Quarantine, United States Department of Agriculture Agricultural Marketing Administration, United States Department of Agriculture Bureau of Agricultural Economics, United States Department of Agriculture Federal Crop Insurance Corporation, United States Department of Agriculture Agricultural Conservation and Adjustment Administration, the State agricultural colleges and experiment stations, the State departments of agriculture, and the State Plant Boards.

Arrangements for the general participation of Federal agencies would need to be made in Washington through their respective heads. If memoranda could be obtained from the heads to State and regional headquarters authorizing field personnel to give such assistance as was possible without serious interference with their regular duties entomologists of the States would then be in a position to contact representatives of the various agencies in their State, outline the reports on insect damage which were desired and act as a clearing house for such reports in their respective States. Committee members, with the approval and assistance of the Chief of the Bureau of Entomology and Plant Quarantine, might be able to secure the necessary authorizing memoranda from heads of Federal agencies in Washington. Responsibility for accumulation of data in the respective States should be placed squarely upon the heads of the strongest entomological organizations within the States. In some cases this might be the State Entomologist, in others the experiment station entomologist, the extension entomologist, or the head of the combined teaching and research staffs. They are the persons most vitally concerned about insect damage in the respective States and would be in the strongest position to make contacts with various agencies within their States. Specialists and personnel of Bureau of Entomology and Plant Quarantine field stations could assist by assembling data on insect damage by the insects in which they were particularly interested and turning this information over to the State Entomologists.

If this plan could be put in operation it might work out as follows: County agents, county A.A.A. committees, county crop insurance committees, state crop statisticians, fruit and vegetable and grain inspectors might be induced to report on damage caused by some of the more common and easily recognized pests. There would be overlapping reports but these would tend to balance each other and could be adjusted by the State Leaders. The job of securing additional information on easily recognized important pests and on insect damage which can be identified and estimated only by trained entomologists would have to be placed upon the entomological staffs of the respective States with such assistance as could be given by Federal entomologists working within the same States. Damage by insects for which no field observations were made would simply have to be rated by the entomologist of the State on the basis of his general knowledge of conditions within the State. At the end of the year all State reports would be sent to a central point for compilation into a national summary.

W. P. FLINT — CLAY LYLE
F. M. WADLEY — J. A. HYSLOP
J. R. PARKER — *Chairman*

REPORT OF THE PUBLICATIONS COMMITTEE OF THE JOURNAL OF ECONOMIC ENTOMOLOGY

The removal of the 6-page limit as recommended by the committee last year has worked out very well. The editor has not been swamped with long articles yet the volume of contributions has kept pace with the times. Thanks to the untiring efforts of the editor the pages in the JOURNAL have been carefully conserved and filled with articles of great value to our members.

Due to the splendid constructive work of the previous chairman of this committee, F. L. Campbell, the present committee has had no particular problems to solve. Our members have passed on special papers that the Editor placed before us for consideration, but outside of this, we have had very little to do.

To serve as the Editorial Board during 1943 the committee suggests to the Nominating Committee the following names:

Editor	L. M. PEAIRS
Honorary Editor	E. P. FELT
Associate Editor	H. B. WEISS
Business Manager	E. N. CORY

Respectfully submitted,
A. G. RUGGLES, *Chairman*

REPORT OF COMMITTEE ON INSECTICIDE TERMINOLOGY

Owing to the pressure of war work the Committee was unable to make sufficient progress to warrant publication of recommendations at this time. It was intended to make a start on definitions and specifications of inorganic, synthetic organic, and plant insecticides and to prepare a list of abbreviations of units of measurement. Some progress was made on inorganic insecticides.—3-18-1943.

F. L. CAMPBELL, *Chairman*

REPORT OF THE COMMITTEE ON CODLING MOTH FOR 1942

By correspondence, your Committee voted unanimously to forego an annual conference of workers interested in codling moth research. It was also voted to continue the annual pool of information and to make a special effort to obtain contributions to the pool from investigators in the United States, Canada and South Africa. The Committee feels that the pool of information has greatly aided research workers in coordinating their efforts and will be of even more value this year, and perhaps for several years, due to lessened opportunity of meeting in groups for discussion. The Bureau of Entomology and Plant Quarantine was requested and has agreed to continue their valuable service in acting as a central agency for collecting the summaries and preparing the pool of information for distribution.

The Committee is of the opinion that the suggestions given in the report on the codling moth for 1941 should be continued with certain revisions and additions. It is believed that the cost of codling moth control has increased out of proportion to the value of the apple crop produced in the principal orchard areas; that there is a need for entomologists interested in the problem to take stock of their investigations and that there is a need for the development of new approaches to the problem. The following suggestions are submitted for consideration in making plans for future work in solving the problem of codling moth control.

1. Abstract all published information on codling moth studies and observations and make copies of the complete abstract available to those persons interested in codling moth research. It is suggested that the Bureau of Entomology and Plant Quarantine take the lead in this undertaking.

2. Continuation of research on substitutes for lead arsenate is needed. The changing of domestic tolerances for lead and arsenic residues has not altered the fact that lead arsenate is inefficient in regions where codling moth injury is severe. Scarcity of the basic materials from which lead arsenate is manufactured during the war period is an added reason for continuing and intensifying the search for substitutes, with special emphasis on nicotine-bentonite.

3. The Committee feels that more attention should be devoted to the study of ways and means of destroying the overwintering larvae and spring pupae; that this is a field of study which has barely been touched upon and if a reasonable proportion of the total research work now being done was devoted to this phase of the problem worth while results might be obtained.

Studies of methods of fortifying lead arsenate as a larvicide should continue with emphasis on the development of chemicals that can be added to lead arsenate sprays to destroy other stages of the insect, particularly the egg and adult.

4. Further attention should be given to the evaluation of strains in certain commercial orchard areas. Studies are also needed to answer the question: Can quick acting stomach poisons or contact insecticides like nicotine-bentonite, phenothiazine, xanthone, etc. lead to the development of resistant or hardier strains?

5. Fundamental studies are needed on physiology with special emphasis on the way insecticides destroy the different stages of the insect or influence the population. In this connection the effect on larvae already inside the apple should not be overlooked. Is the reproductive capacity of the insect or its rate of development affected? Some of the many new materials being tested as insecticides (usually only as ovicides and larvicides) may have entirely unsuspected effects in other ways that might be overlooked.

6. In studies on the habits and behavior of the insect special emphasis should be placed on (1) the relation of the time of moth emergence or moth flights and the time when peaks of larval attacks actually occur, (2) the effects of specific insecticides and adjuvants on the behavior of larvae, adults and natural enemies. Such effects as repellency and attractiveness to adults or larvae might increase or decrease control in limited tests but have little or no effect in large areas. It is also possible that changes in behavior might make the insect more susceptible to other means of control when used in conjunction with a particular insecticide.

7. The reasons for differences in the relative control value of certain insecticides in different regions should be given more attention. It is generally assumed the differences are largely caused by climate, but just how are they responsible? Conflicting reports from different workers may reduce confidence in research unless regional differences are known to exist and their importance emphasized. It is up to the entomologists to show why one insecticide is superior to lead arsenate in one locality but inferior elsewhere.

8. Codling moth research may be improved by the development of more reliable technique in order to make it possible to evaluate properly the many variables with which we must contend. Some workers are limited by time and funds and yet are under extreme pressure for results and cannot give much attention to the ideal technique, or even use reliable technique if it requires more work. For this reason the publication of results should give adequate information concerning methods so that others can at least estimate the reliability of the results.

9. The possibilities of biological control should receive more attention. The committee feels that in due time (possibly after the war) some agency should concern itself with the survey and importation of promising parasites and predators of the codling moth. Such surveys should be made in regions other than the probable origin of the codling moth. It is possible that parasites native to South Africa, South America or elsewhere have transferred to the codling moth which could be introduced to advantage in other apple growing regions.

10. The majority of the Committee feels that entomologists have not taken due advantage of the factor of climate, particularly temperature, in the over all problem of codling moth control. It is common knowledge that in nearly every apple growing state or region there are areas or zones of intensity of codling moth attack. The intensity of attack is generally related to the number of broods per season and this in turn is governed to a large extent by the mean annual temperature during the apple growing season. Thus we find different areas where the codling moth is one, two, three or even four brooded and it is in the three and four brooded areas where the greatest difficulty in control is experienced. It is suggested, therefore, that entomologists in collaboration with horticulturists consider the advisability of gradually shifting apple production from the three and four brooded areas to the one and two brooded areas.

11. Entomologists should give more attention to

the problem of rotation of apple plantings, either by rotating apples with apples or apples with other fruits, as a factor in the control of codling moth. This would seem to be particularly worthy of study in the three and four brooded areas. It is a general observation that codling moth is more easily controlled on younger and smaller trees. In this connection it would seem worth while to study the possibilities of the dwarf and semi-dwarf stocks in areas of severe codling moth attack.

12. There is a need for additional work by entomologists in cooperation with agricultural engineers and spray equipment manufacturers looking toward the development of more efficient machinery for applying sprays. One of the big items in the cost of apple production is the labor and equipment necessary to apply the number of sprays found necessary for adequate control with existing spray combinations.

JAMES MARSHALL L. B. GENTNER
L. F. STEINER EDWIN GOULD
GEORGE M. LIST BYRLEY F. DRIGGERS, *Chairman*

REPORT OF THE COMMITTEE ON THE RELATION OF ENTOMOLOGY TO CONSERVATION

Previous reports of this committee as published in the JOURNAL OF ECONOMIC ENTOMOLOGY (Vols. 31, 32, 33, and 34, No. 1) have made some very strong suggestions regarding closer cooperation between entomologists and agencies dealing with various phases of conservation. Some progress has been made by individuals in getting the need for entomological cooperation placed before conservation workers. The great bulk of the entomologists have done nothing about it, even though they know that some conservation measures are likely to increase the abundance of some economic insect. This in spite of the fact that this committee in its report for 1939 (JOURNAL OF ECONOMIC ENTOMOLOGY Vol. 33, p. 223) urged " . . . the entomologists of the country to participate actively in the planning of conservation measures and to take full advantage of the opportunities offered by conservation work togather and record much needed information on the relation of different types of land and conservation procedures to insect problems.

"The committee invites members of the Association to present to it their suggestions as to how it may aid in coordinating entomological and other conservation work."

Up to the present, the majority of the suggestions have come from the committee, with little information or help coming from members of the Association. Past experience has shown that only in rare instances have men engaged on a conservation project dealing with other than biological sciences invited the entomologist to participate before insect problems became evident. Every entomologist has some information that is invaluable in planning and guiding any conservation project whether in biological or other sciences. Much of this information is unpublished and so is not available except through personal contact. For the good of the conservation project it is the duty of the entomologist to either volunteer information and assistance to the conservation workers or notify this committee, naming the conservation organization, and let the committee bring the two together.

With the great number of agencies throughout North America working on various phases of conservation, it is impossible for this committee to know what or where they all are. If there are members of the Association who are not now cooperating in conservation activities but are willing to do so with some local organization, this committee can play its part by making a suggestion to the conservation group. It must be done, however, on the suggestion being received from the entomologist, since the conservation group probably does not know of the existence of the committee.

Throughout the continent there are a great many experimental stations set up for the study of soil conservation. A host of agriculturalists and engineers are employed at these places working with all manner of implements, farm practices, crop rotations, fertilizers, regrassing schemes, contour stripping, contour ditching and water storage, to prevent wind and water erosion of the soil. In some cases a botanist and chemist are included on the staff. Entomologists at these stations are rare, and yet every entomologist who has worked with field and forage crop or livestock insects knows that some of the things being done under the name of soil conservation are contrary to recommended insect control practices. He knows, also, that the continuation of certain of these operations will tend to increase the insect problems on the farms where these soil conservation recommendations are being carried out in actual practice.

The same is true of other phases of conservation. The entomologist is not playing his full part in the program, particularlythe entomologist resident in or familiar with the particular conditions where the work is being done. Not until the entomologists establish a direct contact with conservation programs and demonstrate that they have something definite to offer, can we expect conservation groups to invite entomological cooperation. Previous reports of this committee have pointed out the need for cooperation between members of the Association and conservation groups and between members of the Association and the committee. We can do no more than recommend that members read these former reports and give the committee an opportunity to put former suggestions to practical use.

F. P. KEEN
H. H. STAGE
H. L. SEAMANS, *Chairman*

REPORT OF THE REPRESENTATIVES ON THE COUNCIL OF UNION OF AMERICAN BIOLOGICAL SOCIETIES FOR 1942

Your representatives on Council of Union of American Biological Societies beg leave to report as follows:

Inasmuch as the principal activity of the Union of American Biological Societies appears to be the sponsorship for Biological Abstracts in cooperation with the American Association for the Advancement of Science and the National Research Council and inasmuch as there appears among the economic entomologists no considerable appreciation of the service which the Biological Abstracts offers, your representatives advise at this time that the American Association of Economic Entomologists take no action relative to Biological Abstracts.

Respectfully submitted
C. L. FLUKE
THOMAS J. HEADLEE

PROCEEDINGS OF THE TWENTY-SEVENTH ANNUAL MEETING PACIFIC SLOPE BRANCH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

University of Utah, Salt Lake City, June 17–18, 1942

The 27th Annual Meeting of the Pacific Slope Branch was quite successful, even though travel restrictions caused a reduced attendance. The interest in the papers and participation in the discussions seemed to be greater on account of the lessened attendance.

The outstanding address of the meeting was given by Dr. P. N. Annand, on "Insect Problems Affecting Food Production." He stressed the importance of the various problems now facing the entomologists in connection with our national efforts to produce sufficient food for ourselves and our allies.

The discussion on "What can we as entomologists do to be of most service to our country" was participated in by most of those present and brought out many interesting viewpoints. It was shown that the entomologist has a place in the armed forces where his training and experience are needed in connection with insect problems affecting the health of the military units, and in the protection of food or other stores from insect damage. It was also brought out that the efforts of entomologists in civilian life, whether in research, teaching, or extension, should be concentrated on the control of insects affecting food and other materials needed by the military and civilian forces in our war effort.

Two very fine colored motion pictures were shown, one by Dr. A. J. Cox, Chief of the Division of Chemistry of the California Department of Agriculture, the subject of which was "The Story of Economic Poisons." This showed the making and application of our various economic poisons. The other motion picture was "Combat," by the General Chemical Company, showing the fight against insect pests and plant diseases in the principal fruit and vegetable producing areas of the country.

The total attendance was 65, and the following members were among those present:

Annand, P. N.	Washington, D. C.
Brindley, T. A.	Moscow, Idaho
Campbell, Roy E.	Alhambra, Calif.
Dohanian, S. M.	Eugene, Ore.
Douglass, J. R.	Twin Falls, Idaho
Doyle, E. T.	San Francisco, Calif.
Fenton, Alfred	Houston, Tex.
Fracker, S. B.	Washington, D. C.
Fronk, Don	Ogden, Utah
Johnson, Esler	San Francisco, Calif.
Knowlton, G. T.	Logan, Utah
Lane, Merton C.	Walla Walla, Wash.
Mote, Don C.	Corvallis, Ore.
MacLeod, G. T.	Berkeley, Calif.
Peay, W. E.	Logan, Utah
Richards, Claude A.	Arcadia, Calif.
Sorenson, C. J.	Logan, Utah
Webster, B. L.	Pullman, Wash.
Wampler, E. L.	El Segundo, Calif.
Yust, Harold R.	Whittier, Calif.

BUSINESS SESSION

Committees appointed at the opening session reported at the final business session, as follows:

RESOLUTIONS: Be it resolved that the very sincere thanks of the members of the Pacific Slope Branch of the A.A.E.E. be extended to the many agencies who have contributed to the enjoyment of this meeting—Newhouse Hotel, Wasatch Chemical Co., A-1 Sugar Co., Fisher Brewing Co., all of Salt Lake City, and the Tobacco By-Products & Chemical Corp. of San Francisco, and Texas Gulf Sulphur Co. of Houston, Texas. Be it further resolved that the group express its appreciation for the efforts of the local members, particularly Dr. George Knowlton and Prof. C. J. Sorenson, Dr. Don N. Rees, Mr. W. E. Peay, and Dr. V. M. Tanner, for the successful handling of the innumerable details connected with the planning and conduct of the meeting. Be it further resolved that our thanks be extended to all those who arranged the delightful organ recital given by organist Setreiner and the reception at the Lion House.

Respectfully submitted,

E. L. WAMPLER G. F. MACLEOD
ALFRED FENTON *Chairman*

Treasurer's Report:

June 18, 1941, Balance on hand		$16.03
July 28, 1941, Refund for 1940–41 expenses		48.58
Express & postage on proceedings	$ 1.71	
Postage & postal cards	2.40	
Mailing announcements	9.60	
Mimeographing notices	7.25	
Multigraphing program	10.82	
Expenditures	31.78	
June 13, 1942, Balance on hand	32.83	
	$64.61	$64.61

Accounts audited and approved by
J. R. DOUGLAS
S. M. DOHANIAN

ROY E. CAMPBELL
Secretary-Treasurer

Vice President S. B. Fracker brought greetings from President Weiss, and regrets that he could not attend. He also reported on certain resolutions passed at the 1941 Pacific Slope Branch meeting, and commented on the recent questionnaires sent out by the Joint Committee for Effective Utilization of Entomological Personnel and Facilities during the War, stressing the importance of filling out the form fully and sending it in promptly.

New officers elected were:

Chairman: Merton C. Lane, Walla Walla Wash.
Vice-Chaiman; K. W. Gray, Corvallis, Oregon
Secty-Treas.: Roy E. Campbell, Alhambra, Calif.

It was announced that the 1943 meeting would be held at Oregon State College, Corvallis, Oregon, the 3rd week in June.

ROY E. CAMPBELL, *Secretary*

THE EASTERN BRANCH

The Eastern Branch held its fourteenth annual meeting at the Hotel New Yorker, New York City, on November 19 and 20, 1942. The program consisted of 31 papers and a round-table discussion on alternate insecticides. The attendance was approximately 125 and the interest was good during all sessions. The Report of the Special Committee on *Entoma* was received by the Branch with favorable consideration, and the publication of a 1943 edition of *Entoma* was approved. Receipts for the year amounted to $432.17 and disbursements to $1,356.76, leaving a balance in the treasury of $1,999.72. The following officers were elected for the coming year: M. P. JONES, *Chairman*, HUGH GLASGOW, *Vice-Chairman*.

HARRY B. WEISS, *Secretary*

SEVENTEENTH ANNUAL MEETING COTTON STATES BRANCH

The Seventeenth Annual Meeting of the Cotton States Branch of the American Association of Economic Entomologists was held in Memphis, Tennessee on February 3, 4, 5, and 6, 1942. The meetings were held in the same city and at the same time as the Annual Meetings of the Association of Southern Agricultural Workers.

The convention featured two symposia, one dealing with boll weevil control and the other with the control of insects affecting stores grains.

There was a total membership increase in the Cotton States Branch of thirty-three and a net increase of ten.

The secretary-treasurer reported total receipts of $393.72 and disbursements of $182.31, with a balance of $211.41.

Officers elected for the year 1942–43 were: O. W. Rosewall, Chairman; E. W. Dunnam, Vice-Chairman; and John T. Creighton was elected Secretary-Treasurer for a new three year term.

The membership of the Branch voted to meet in 1943 in the city of New Orleans. They also voted to hold the 1944 meetings in conjunction with the parent organization during the Christmas holidays in 1943 in San Antonio, Texas.

JOHN T. CREIGHTON
Secretary-Treasurer

FLORIDA ENTOMOLOGICAL SOCIETY

Because of the large number of entomologists in the vicinity of Orlando and in consideration of the restrictions on travel, the 1942 annual meeting of the Florida Entomological Society was transferred from Gainesville to Orlando. The meeting was held in the San Juan Hotel, December 11 and 12 with President K. E. Bragdon presiding. The register of attendance showed that nineteen members and twenty-five visitors were present.

"Let's get closer to the farmer," was the theme chosen by President Bragdon as the topic for his address. He urged entomologists to devote as much effort as possible to insect control problems as an aid to the war effort of the nation. Mr. Bragdon suggested three ways that entomologists can aid farmers. They were (1) that information in Federal and State bulletins on insect control be stated in simple, clear language that farmers can understand, (2) that insecticide companies give more emphasis to the ingredients of their insecticides and less to publicizing trade names, and that they discontinue shotgun remedies supposed the control all insects that may attack a crop, and (3) that all entomologists make a special effort to help all farmers with their insect problems and not just those who ask for aid.

On Friday afternoon the members of the Society visited the U.S.D.A. Laboratories where Dr. E. F. Knipling and members of his staff showed and explained the methods employed in investigations of the various projects.

Other papers presented were by C. B. Wisecup, Recent Developments in Mole Cricket Investigations; J. R. Watson, Some Notes on Thysanoptera, and Natural Control of Nematodes; John M. Frederick, Investigations of the Green Scale, *Coccus viridis* (Green) in Southern Florida; W. L. Thompson, Injury and Control of Purple Mites on Citrus; Dean F. Berry, Sidelights of Collecting in Florida; Hiram C. Young, The White Fringed Beetles; R. L. Miller, War and Its Effects on the Insecticide Industry; Homer Hixson, Some Notes and Observations on the Natural Reduction of Anopheles Mosquito Larvae in Certain Environments; and A. N. Tissot, History of the Mexican Bean Beetle in Florida. Dean F. Berry exhibited an interesting display of Florida Hesperidae.

On Friday evening fifty-two entomologists and guests enjoyed the annual banquet of the Society. Mr. W. W. Yothers very capably served as toastmaster and introduced the speakers. Dr. E. F. Knipling gave the adress of welcome and Prof. J. R. Watson made the response. Mr. Yothers paid tribute to two venerable and esteemed members, Doctors Herbert Osborn and H. T. Fernald who as usual were present to enjoy the occasion. The principal speak was Major J. Q. A. Daniels, Sugreon at the Army Air School at Orlando. Major Daniels spoke of the importance of entomology in helping to maintain the health and well being of the men in the armed services and mentioned some of the difficulties that must be overcome before the findings made in the laboratories can become available to the men in the ranks.

Officers for 1943 are: T. H. Hubbell, *President;* A. H. Madden, *Vice-President;* C. B. Wisecup, *Treasurer;* A. N. Tissot, *Secretary;* and J. R. Watson, Editor of the Florida Entomologit.

A. N. TISSOT, *Secretary*

THE NEWELL ENTOMOLOGICAL SOCIETY

In lieu of war conditions the Newell Entomological Society of the University of Florida cancelled the official Annual Florida Entomological Conference. However, an informal meeting was held on May 1, 1942, which was well attended by professional entomologists and students. Interesting papers of a local character and others pertaining to the war were presented.

The Newell Entomological Society membership in active students has decreased somewhat due to the entry of young men into the armed services.

The membership voted to purchase annually a defense savings bond from its annual funds.

The Newell Entomological Society *News* was published twice during the scholatic year 1941–42 and the May issue was dedicated to the twenty-seven members in the armed services. Mr. Robert Morris was editor of the News.

Bi-weekly meetings have been held at which time state and local speakers have appeared.

The present officers of the Society are: Sam Walkup, *President;* T. T. Hatton, *Vice-President;* Jack Ingle, *Secretary-Treasurer;* James Heidt, *Reporter;* and John T. Creighton, *Faculty Advisor.*

REPORT OF TRUSTEE OF THE TROPICAL PLANT RESEARCH FOUNDATION

To the American Association of Economic Entomologists:

There is little to report concerning the activities of the Foundation during the past year as there have been no allotments for special projects and there is no immediate prospect that such projects will be undertaken in the near future. I may report however that there is a possibility that the Foundation may

deem it best to assign its resources, including the library, to some organization which may be in a position to enlist active participation in Tropical Research in future years. No definite policy has been adopted but it is probable that action may be taken at a meeting next May, at which it is expected the whole question of further activities may be determined.

HERBERT OSBORN, *Trustee,*
Tropical Plant Research Foundation

REPORT OF THE COMMITTEE ON COMMON NAMES

Only eight proposals for new common names were carried over from 1941; and, in accordance with a decision of the Executive Committee at San Francisco, no ballot on common names was prepared in 1942 for distribution to the Association membership. However, a comprehensive list of all common names approved by the Association through 1941 was published in the February 1942 number of the JOURNAL. Through some accident the Committee's corrected proof did not reach the printer and the published list, unfortunately, contains a considerable number of typographical errors. Nearly all of these were corrected in the separate copies of the list that were printed subsequently.

Proposals for new common names on hand at the end of 1942 total 32. In addition, one change in an approved common name has been suggested. Normally such an accumulation would warrant special balloting; but in view of the disturbed conditions resulting from the War it is recommended that no ballot be prepared in 1943 and that the accumulated proposals be incorporated in a later ballot.

PHILIP GARMAN
R. T. COTTON
B. G. THOMPSON
RAY HUTSON
JOSEPH WILCOX
C. F. W. MUESEBECK, *Chairman*

REPORT OF COMMITTEE ON GRASSHOPPER RESEARCH

The Committee on Grasshogper Research appointed in 1942 by Harry B. Weiss, President of the American Association of Economic Entomologists, has prepared and has ready for distribution its first report. The information which is included in this report deals with research work done with grasshoppers principally during the past year. In some instances the report covers work done during one or more years previous to 1942. In some cases the reports are progress reports; in others, they are summaries of projects that were completed. While the summaries deal principally with economic, ecologic and taxonomic studies of grasshoppers, it was not intended to exclude other phases of grasshopper research work from the report. The material in this report is not for publication, and therefore, should not be quoted or otherwise used without specific permission from the agency which has furnished it.

The report appears in three parts. Part one includes a report of the work done principally by State Agencies of the United States and has been prepared and edited by H. C. Severin, State Agricultural Experiment Station, Brookings, S. D. Part two includes the work done by the United States Board of Entomology and Plant Quarantine and has been prepared and edited by J. R. Parker, Bozeman, Mont. Part three includes the work done in Canada and embraces the work done by the Dominion as well as the Provincial workers. This part has been prepared and edited by R. D. Bird, Dominion Entomological Laboratory, Brandon, Manitoba. For copies of parts 1, 2 and 3, the interested individuals should write to the editors whose names and addresses are given above.

J. R. PARKER
F. A. FENTON
G. A. DEAN
R. D. BIRD
K. M. KING
H. C. SEVERIN, *Chairman*

ENTOMOLOGICAL SOCIETY OF PENNSYLVANIA

The 20th Annual Meeting of the Entomological Society of Pennsylvania was held at Harrisburg on January 12 with Vice-Chairman C. F. Campbell presiding.

J. O. Pepper, H. E. Hodgkiss and John Deal reported on the efforts of extension to provide the public with entomological information during wartime through all publicity channels and in close cooperation with the County Agents.

R. A. Sheals spoke on efforts to control Gypsy moth by airplane dusting. S. S. Crossman reported on new methods and preparation of materials for the trapping of Gypsy moth. C. F. Campbell reported that the local infestation of Gypsy moth was being held well within old boundaries. J. M. Corliss reported on methods used in handling transit inspection concerning Federal and State quarantines. Tom Guyton reported on corn borer surveys in the single and in the two generation areas noting considerable increases in infestations in Adams and York Counties. He also told of the cooperative effort with the U. S. Bureau of Entomology and Plant Quarantine made in distributing milky diseases of the Japanese beetle especially in Lancaster and York Counties. G. B. Stickter, G. B. Sleesman, A. B. Champlain and E. M. Craighead spoke on various phases of inspection and certification work done at several points in the state. H. M. Steiner reported on the progress of fruit insect research in Southern Pennsylvania.

Officers for the coming year are: *President*, C. F. Campbell; *Vice-President*, H. M. Steiner; *Secretary*, G. B. Sleesman.—1-18-43.

HAROLD STEINER, *Secretary*

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AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Organized 1889; Incorporated December 29, 1913

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Barnes, Olus L., U. S. Ent. Lab., Tempe, Ariz.

[1] Please advise the Secretary promptly of any change of address.
[2] Mail has been returned from a number of members. The Secretary will appreciate any information concerning them.
[3] Military rank and other information about members in the service will be found in the Military roster published from time to time.

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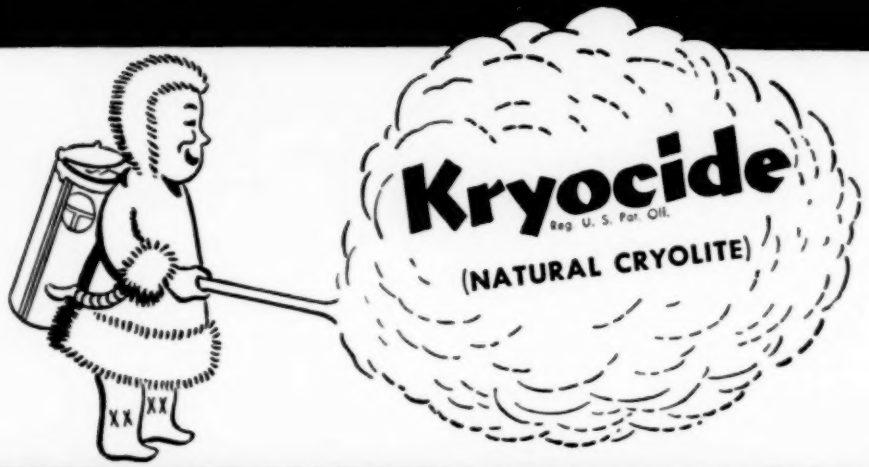

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